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INTERNATIONAL PHYTOPATHOLOGY AND QUARANTINE LEGISLATION[1]

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INTRODUCTION

It is the purpose of this paper to discuss the problems of international phytopathology with especial reference to the needs developed in applying legislative means for the control of plant diseases, and to present for the information of the Society an outline of the new Federal Plant Quarantine Act.

Until a few months ago there were no laws conferring on the government authority to take precautionary measures against the introduction into the United States of foreign insects and plant diseases or to restrict the spread of pests already here. Trade in nursery stock and plant products was then governed only by the laws of the several states, and although most of these were maintaining some kind of inspection service, there were many gaps through which diseased material could slip. This situation was in striking contrast to the prohibitory laws enforced for many years in other countries, particularly against American plants, and the incalculable losses suffered by American agriculture and horticulture from the San José scale, the gypsy and brown-tail moths, peach yellows, and other troubles emphasized the need for action.

The persistent efforts of the last fifteen years resulted last summer in the passage by Congress of the Simmons Bill, which became the Plant Quarantine Act, August 20, 1912. The essential features of the law are outlined below. The full text with the regulations is printed in a circular of the Department of Agriculture.[2]

[1] Read at the Symposium on International Phytopathological Problems before the American Phytopathological Society, January 2, 1913.

[2] Circular 44, Office of the Secretary, U. S. Dept. of Agric. Sent free upon application. See also Notices of Quarantine, Nos. 1 to 6 inclusive, and Quarantine Decisions, Nos. 1 and 2.

SCOPE OF THE LAW

The law does not impose a general quarantine against all plant diseases, but only against those which, after having been shown to be new and dangerous, are made the subject of special quarantine orders. Regulations are provided for the importation and inspection of nursery stock, which the law defines to include "all field-grown florists' stock, trees, shrubs, vines, cuttings, grafts, scions, buds, fruit pits, and other seeds of fruit and ornamental trees or shrubs, and other plants and plant products for propagation, except field, vegetable, and flower seeds, bedding plants, and other herbaceous plants, bulbs, and roots."

This definition may be extended by the Secretary of Agriculture to include any of the excepted plants or plant products whenever it shall appear that their unrestricted importation might result in the entry of injurious insects or plant diseases. This has been done in several cases by the quarantine orders mentioned later.

PERMITS

In order that all imported nursery stock may be inspected, the law provides machinery to insure that notification of every shipment is sent to the proper inspection officer. The importer must first secure a permit from the Department of Agriculture, which authorizes him to import nursery stock from a specified firm and locality for a specified period, usually until June 30 following. If this permit is lacking, the customs officer refuses to admit the goods to entry. The importer need not specify in his original application the character and quantity of the stock, but immediately upon its arrival he must give the customs officer, for transmission to the Department of Agriculture, a statement of this nature, including destination. He must mail a copy at the same time to the inspector in the state of destination. The Department of Agriculture also notifies the state inspector, who reports back the result of his examination.

INSPECTION

All inspection of nursery stock, except that from countries maintaining no inspection service, and consequently unable to grant the certificates required by our law, is at point of destination, and is performed by state officials. The law does not authorize federal port of entry inspection, except as hereafter noted.

It is a pleasure to acknowledge the hearty support and coöperation that has been given by the state officials everywhere. As an indirect effect of the new law, several states have strengthened their inspection service

by extending the powers of their inspectors and granting additional financial support.

FOREIGN CERTIFICATES

The law requires that no nursery stock shall be admitted unless "accompanied by a certificate of inspection, in manner and form as required by the Secretary of Agriculture, of the proper official of the country from which the importation is made, to the effect that the stock has been thoroughly inspected, and is believed to be free from injurious plant diseases and insect pests."

During the present season, the forms of certificates previously in use have been accepted, but after July 1, 1913, it will be required as a requisite for customs entry, that "the invoice be accompanied by an original certificate, and each container bear a copy-certificate, issued by a duly authorized official of the country from which it is exported, stating that the nursery stock *covered by the certificate* has been thoroughly inspected by him or under his direction and found, or believed to be, free from injurious plant diseases and insect pests. Nursery stock exported between October 1 and May 31, shall be inspected on or after the first of October, and stock exported between June 1 and September 30 shall be inspected at the time of packing."

"Nursery stock from countries which do not maintain official nursery stock inspection will be admitted into the United States *only for experimental purposes and in limited quantities*, under special permit, through ports designated therein. Such nursery stock shall not be delivered to the importer or consignee until it has been examined by an inspector of the Department of Agriculture and found to be free from plant diseases and insect pests, as defined in the Act." It is provided, however, that if the stock can be cleaned by treatment, this may be done, and a regulation defines the procedure to be followed.

This section of the regulations is of especial interest to the phytopathologists and those interested in plant introduction, since it is from countries having no inspection services that we are seeking many new plants for experimental purposes. However great may be the future promise from such introduction, there is equal danger that they may bring with them hitherto unknown pests, which, like the San José scale, may spread to other crops. The plan to limit and control such introduction should, therefore, receive general support.

PLANT QUARANTINES

Authority is granted by the law to prohibit the importation of any plant or plant product whenever necessary to prevent the introduction of

"any tree, plant, or fruit disease or of any injurious insect, new to or not theretofore widely prevalent or distributed within and throughout the United States." Under similar circumstances, a domestic quarantine may be issued restricting interstate trade in the plants or products affected.

The following Quarantine Notices have been issued:

No. 1, dated September 16, 1912, prohibits the importation of four species of pine (*Pinus strobus* L., *Pinus monticola* Dougl., *Pinus lambertiana* Dougl., and *Pinus cembra* L.) from Great Britain, France, Belgium, Holland, Denmark, Norway, Sweden, Russia, Germany, Austria, Switzerland, and Italy, on account of the white pine blister rust (*Peridermium strobi* Kleb.) This order has since been made more stringent. Cf. Quarantine Notice No. 7.

No. 2, dated September 18, 1912, prohibits the movement from Hawaii into or through any other part of the United States of thirty fruits and vegetables liable to infestation by the Mediterranean fruit fly (*Ceratitis capitata*).

No. 3, dated September 20, 1912, prohibits the importation of potatoes from Newfoundland; the islands of St. Pierre and Miquelon; Great Britain, including England. Scotland, Wales, and Ireland; Germany; and Austria-Hungary, on account of the potato wart (*Chrysophlyctis endobiotica*, Schilb.)

No. 4, dated November 5, 1912, quarantines the districts in New England infested with gypsy moth and brown-tail moth, and provides regulations for the movement of plants and forest plant products therefrom.

No. 5, dated January 15, 1913, prohibits the introduction into the United States from Mexico of seven fruits liable to infestation by the Mexican fruit fly (*Trypeta ludens*).

No. 6, dated March 1, 1913, quarantines certain districts in California, Arizona, and Texas, on account of the date palm scale insects *Parlatoria blanchardi* and *Phoenicococcus marlatti*, and provides regulations for the treatment and interstate transportation of date palms.

No. 7, dated May 21, 1913, extends the quarantine against the White Pine Blister Rust by prohibiting the importation of all 5-leafed pines from all countries of Europe and Asia.

IMPORTATIONS FOR SCIENTIFIC PURPOSES

The Department of Agriculture is authorized to import nursery stock for experimental or scientific purposes, subject to conditions and regulations prescribed by the Secretary. It has been arranged to have such importations handled by the Office of Foreign Seed and Plant Introduction, in charge of Mr. D. G. Fairchild, and a thorough inspection for insects and diseases made.

Other institutions desiring to import plants for scientific or experimental purposes from countries not under quarantine, may secure permits in the same manner as private firms.

Under an amendment passed March 3, 1913, any class of plants the importation of which is prohibited by quarantine may be brought in for experimental or scientific purposes by the Department of Agriculture only. Special safeguards are thrown by Departmental regulations around such importations.

SHIPMENTS BY MAIL AND PARCELS POST

There has been hearty coöperation by the Postmaster-General in adjusting the postal service to the new quarantine law. It was early found impracticable to inspect at destination small mail shipments of nursery stock, and these frequently came without the certificates and marking required. It is evident that the danger from mail shipments is in many ways greater than from larger consignments of nursery stock. The Post Office Department has recently issued an order, effective July 1, 1913, which renders nursery stock unmailable in the International Parcels Post, except when intended for and addressed to the United States Department of Agriculture.

The domestic mails are open to nursery stock accompanied by an inspection certificate and marked to show nature of contents and name and address of sender. Other orders[3] of the Postmaster-General assist in the enforcement of the special quarantines by rendering certain Hawaiian fruits unmailable and by requiring special certificates for certain plants grown within the area covered by the gypsy and brown-tail moth quarantine.

PUBLIC HEARINGS

A valuable feature of the law is the requirement that public hearings be held, after due notice, before the promulgation of an order modifying the definition of nursery stock, or placing a foreign or a domestic quarantine.

PENALTIES

Violation of the law is a misdemeanor, to be punished by a fine not exceeding five hundred dollars or by imprisonment not exceeding one year, or both. Permits may be cancelled and further permits refused, for the

[3] Nos. 6655, November 16, 1912; 6674 and 6675, November 27, 1912; and 6696, December 4, 1912. See also, Marlatt, C. L., The federal plant quarantine act, Journ. of Econ. Entomology **6**: 133–142. 1913.

importation of the products of any grower or exporter who has knowingly shipped into the United States any nursery stock or other plants or plant products the importation of which is forbidden, or who fails to give either of the notices required, or gives a false notice, or knowingly mislabels any nursery stock with intent to evade any provision of the Act or of any regulation thereunder.

THE FEDERAL HORTICULTURAL BOARD

For the enforcement of the Plant Quarantine Act there is appointed by the Secretary of Agriculture a Federal Horticultural Board, of five members appointed from the Bureau of Entomology, Bureau of Plant Industry, and the Forest Service. As first organized the Board consisted of C. L. Marlatt, Chairman, A. F. Burgess, W. A. Orton, Vice Chairman, Peter Bisset, and Geo. B. Sudworth. Mr. Burgess was succeeded on January 21, 1913, by W. D. Hunter, and Mr. Bisset on April 3, 1913, by A. V. Stubenrauch. The headquarters are in Washington. In addition to the clerical force there is an entomological inspector, E. R. Sasser, and a pathological inspector, Perley Spaudling. In the field work much assistance is rendered by state officials, acting as collaborators of the Board.

INTERNATIONAL PROBLEMS IN QUARANTINE ADMINISTRATION

Perhaps no country is more concerned than the United States in the international problems involved in the suppression or control of plant diseases. In bringing a new continent under cultivation we are establishing agriculture under many diverse conditions of soil and climate. We are adding to the cultivated plants of the new world all that may be introduced from the old world, and we are breeding new crops and new varieties, into which we are weaving hitherto uncultivated or unknown strains from distant climes.[4]

Furthermore, during the pioneer stages of our agriculture wide areas have been continuously cropped without observing the rotation practices into which experience has led the older nations, thus favoring the development and spread of parasites. In these and in other ways, we are disturbing the equilibrium which nature maintains between plants and their parasites. We have brought in many of the common diseases of Europe, which have proven more virulent here than at home, and we have established here the culture of European plants which have become attacked

[4] Swingle, Walter T. The fundamentals of crop improvement. U. S. Dept. of Agric. Bur. of Pl. Ind. Cir. 116. March 8, 1913.

by American diseases.[5] Both of these processes will be repeated in the future, but it is our problem to reduce the spread of diseases to a minimum.

IS PROHIBITION BETTER THAN REGULATION?

One procedure, followed by several countries, is to prohibit all plant importations. This policy, though perhaps the most effective safeguard, has not prevented the entry of some pests, while it has restricted development. We appear on the other hand to be committed to a policy of regulation, for the people of the United States prefer at present to purchase freely the products of European nursery skill and import their fruit and rose stocks, bay trees, azaleas, bulbs, etc., if it can be done without serious risk of future injury. The imports of such nursery stock into the United States are quite large.

It is at this point that the difficulties involved in protecting ourselves by our own inspection service emphasize themselves. It is utterly impracticable, under present conditions, to examine at the port of entry the imported nursery stock, coming as it does in great volume during a few months, when the dockage facilities are overcrowded. The perishable nature of the stock and the expense involved in repacking constitute additional very serious obstacles. The time to examine stock is when it is dug and packed. An efficient inspection in the country of origin will greatly reduce our danger, but at this point the need of closer international relations becomes apparent, for the inspection should be not only against insect pests and diseases in general, but specifically to insure freedom from certain of the more dangerous enemies such as the brown-tail moth.

Some countries, notably Holland, already maintain effective nursery inspection, but in most cases an improvement is to be hoped for. The effect of our Plant Quarantine Act and the action of the Board in reporting back to the country of origin cases of infestation discovered by the American inspectors, has already been marked in several instances. The foreign certificates will ultimately stand for clean nurseries.

There is great need for international research to strengthen this work, for we are at present distressingly ignorant of pathological conditions in other countries. It would be possible to determine the dangerous character of certain parasites in time to take measures to prevent their introduction. The writer has been assured by competent authority that there are insects in Europe more dangerous to us than the gypsy moth, and he

[5] Orton, W. A. The development of farm crops resistant to disease. U. S. Department of Agriculture, Yearbook **1908**: 453–464. 1909. Orton, W. A. The development of disease-resistant varieties of plants. IV[e] Conference internationale de genetique, Paris, 1911, pp. 247–265, figs. 9, 1913.

is convinced that a similar statement may be made regarding fungus troubles. Probably the danger of bringing pests from the Orient is even greater.

The organization of research along international lines should be on a broad basis, for as pointed out by Shear[6] the pathological conditions differ greatly and the climatic factors are of great importance. Diseases that are of little consequence in Europe may be serious in America, and vice versa. An interchange of visits between European and American workers would throw these points into bolder relief, but a further step is highly to be desired, namely, the formation of an International Committee on Phytopathology, for the purpose of securing closer relationships between the scientific workers in the several countries and to promote research along lines of international interest. Such a committee might stimulate the organization of Plant Disease Survey agencies in each country, to record the geographic distribution of the diseases of plants and their annual prevalence. Reports on the losses caused would enable the economic importance of the subject to be better understood. Epidemic outbreaks should be studied in relation to the weather, crop distribution, and other factors. Data should be gathered bearing on the problems of parasitism, especially in its relation to the adaptation of plants to their environment and the disease resistance or susceptibility of varieties. The coördination of meteorological data should be sought for, so that direct comparisons bearing on plant pathology may be made. Special observations, such as the relative atmospheric humidity in comparison with soil moisture, might be of great service.

It will be noted that emphasis has been placed on the research phases rather than on the idea of governmental agreements for the regulation of trade. The latter viewpoint seems to have been in the minds of those present at the International Congress of Comparative Pathology last September,[7] where an international conference was urged for the purpose of formulating an international agreement along the lines of the Berne Convention. The latter related to the control of Phylloxera by the establishment of quarantined areas, restriction of trade in products of the vine, certification of freedom of plants from disease, etc. It has later been proposed by Cuboni[8] that the terms of this conventon be extended to other plants than the grape. In so far as this would provide a better means

[6] Phytopathology **3**: 61. April, 1913.

[7] L'entente internationale pour la lutte contre les maladies des plantes. Jardin. **25**: 354. Paris, December 5, 1912.

[8] Cuboni, Guiseppe. The basis of an international agreement for the control of plant diseases. Bureau of Agricultural Intelligence and of Plant Diseases (Rome). Third year. Bulletin **11**: 2349–2354. November, 1912.

for the inspection and certification of nursery stock, it is to be recommended. Let us hope, however, that the need for more knowledge will not be overlooked. The present is a period of general interest in this subject on both sides of the Atlantic, and the outlook for action of a favorable nature is most gratifying. May we not assure our colleagues of other countries of our active support of the movement?

HERPOTRICHIA AND NEOPECKIA ON CONIFERS

W. C. Sturgis

With Plates XII and XIII

In the course of a trip through northern Wyoming in the late summer of 1902 I was struck with the extraordinary prevalence of a fungus, unfamiliar to me, infesting the leaves and twigs of *Abies lasiocarpa* and *Picea Engelmanni*. The fungus occurred only on comparatively young trees from five to ten years of age and presented the appearance of a felt-like growth of dark brown mycelium spreading over and involving the leaves, often to such an extent as to hide them from view (pl. XII, fig. 4.) Later, as the leaves died and became detached from the branchlets, the whole mass of mycelium and intermingled leaves could easily be removed intact. Closer examination revealed the presence of numbers of perithecia completely immersed in the felted mycelium except for the slightly prominent ostiola (pl. XIII, fig. 1). A quantity of material was collected and dried for further study.

In September of the following year and in about the same locality I encountered a grove of *Pinus Murrayana*, the leaves of which were infested with what appeared to be precisely the same fungus, and again much material was saved (pl. XII, figs. 1–3).

On examining later the gatherings of these two seasons, I was suprised to find that, notwithstanding the striking similarity of their external appearance, they belonged to two widely separated genera. The specimens collected in 1902 on Abies and Picea proved to be *Herpotrichia nigra* Hartig, while those found in 1903 on Pinus were plainly referable to *Neopeckia Coulteri* (Pk.) Sacc.

Inasmuch as neither of these fungi appears to have figured at all prominently in the literature of fungus diseases in North America, and since, in addition, the synonomy of both seems somewhat confused, the following notes may be of value.

Herpotrichia nigra Hartig

This fungus was first reported by Hartig and was described and figured by him in the Allgemeine Forst- und Jagdzeitung for January, 1888. In Hedwigia **27**: 12–15, it is refetred to by the same author as occurring in Bavaria on *Picea excelsa, Pinus montana, Juniperus communis* and *J. nana.*

Hartig also states that it had been found on the last-named host in Norway.

He describes the dark-brown, matted mycelium, the immersed perithecia attaining a diameter of 0.3 mm., the asci 76 to 100μ by 12μ, and the spores biseriate in the asci, uniseptate when immature, 4-celled later.

Hartig implies that the spores are hyaline; hence Saccardo, copying the original description writes (Syll. Fung. **9**: 858. 1891), "an potius Enchnosphaeria?"

Berlese (Icon. Fung. **1**: 105. Tab. ciii, fig. 1. 1892) transfers the fungus to the genus Enchnosphaeria and questions the supposed identity of *E. nigra* and *E. pinetorum* Fuck., a supposition due to the fact that Saccardo had recorded under the latter name a fungus collected in France, which is unquestionably *Enchnosphaeria* (*Herpotrichia*) *nigra*. (Michelia **2**: 596.)

Berlese's conclusion that the two are distinct is borne out by his drawings. Of this author's and Saccardo's reference of the "sterile mycelium" to *Rhacodium Therryanum* I shall speak later.

Tubeuf (Pflanzenkrankheiten, p. 215. 1895) writes "*Herpotrichia nigra*" again and gives an excellent figure of an infested branch of Pinus. He also figures the 3-septate, mature and germinating spores, but gives no indication that they are other than hyaline at maturity.

Finally Sorauer (Handb. d. Pflanzenkrankheiten **2**: 227) condenses his predecessors' accounts of this fungus, using the original name.

I find but one reference to *Herpotrichia nigra* in American literature, (F. S. Earle in Greene's Plantae Bakerianae **1**: 27. 1900), the reference being to a specimen gathered in Colorado. A brief sentence in Ellis & Everhart's North American Pyrenomycetes, p. 147, mentions the fungus, but merely by way of drawing a comparison between this species and *Lasiosphaeria* (*Neopeckia*) *Coulteri*. These authors state that the spores of the specimen of *Herpotrichia nigra* distributed by Allescher & Schnabel (Fung. Bav. No. 70) are hyaline. This statement is based on insufficient observation; as a matter of fact the spores in the specimen referred to are distinctly olivaceous when mature (pl. XIII, figs. 2 and 3).

Here, then, we have a fungus recorded but once from America, but common in Europe, occurring in France, Bavaria, Norway and Sweden on *Picea excelsa*, *Pinus montana*, *Juniperus communis* and *J. nana;* but never, be it noted, on Abies. It is interesting therefore, to find it occurring in great abundance on both Abies and Picea in the United States. It is further of interest to note that, whereas all previous authors appear to agree in stating that the mature spores are hyaline, and are therefore constantly tempted to throw this fungus into the genus Enchnosphaeria, my own observations, especially in the case of American specimens, lead me to conclude that such is not always, or even normally, the case. Thus

in the specimens distributed by Allescher & Schnabel above referred to, the spores are at first 1-septate and perfectly colorless; later they become 3-septate, but still remain hyaline though they are capable of germination at this stage; only at the extreme of maturity do they become olivaceous in color. The same is true of my specimens on Picea; hyaline and 2-celled when young, each cell being markedly pyriform in shape, it is only at full maturity that they become 4-celled and acquire a color rather darker than in the Bavarian specimens (pl. XIII, figs. 4 and 5). My specimens on Abies show a still further development, the spores while still barely differentiated in the asci being often 3-septate and dilutely fuscescent, while at maturity they are as dark as in any Chaetosphaeria (pl. XIII, figs. 6 and 7).

Through the courtesy of Mr. C. L. Shear, of the U. S. Department of Agriculture, I have been enabled to examine a fairly large series of specimens of Herpotrichia on Abies and Picea collected in 1898 and the two following years in Colorado and Oregon. In such of these specimens as show mature fruit the spores are always colored when ripe, the color being more pronounced when Abies is the host. The series includes one specimen on *Abies concolor*, a new host for this fungus.

Herpotrichia matures its spores remarkably early in the season, considering the group to which it belongs. The Bavarian specimen above referred to was collected in June; my Wyoming gatherings were made early in September; while those collected by Mr. Shear, bear dates from August 23 to September 1. The Bavarian specimens can hardly be considered as fully mature. None of Mr. Shear's specimens show mature fruit before August 14. Mine, collected after September 1, are all mature. Both the asci and the spores of this fungus are extremely fugacious; very shortly after maturity the ostiola of the perithecia are seen to have broken away and not a trace of the former contents remains.

The mycelium of this fungus is usually sterile, so far as conidia are concerned, in the specimens which I have examined. In the Bavarian specimens however, as well as in one from Wyoming on Picea, there are occasionally to be found large, olive-brown, 3 to 6-septate conidia, borne singly on the erect tips of the coarse hyphae (pl. XIII, fig. 8). This fact places the mycelium hitherto known as *Rhacodium Therryanum*, in the genus Helminthosporium.

One further point regarding the mycelium requires elucidation. Hartig was of the opinion that the hyphae in contact with the cuticle of the host were provided with minute haustoria concerning which he writes as follows: "Die stabförmigen Saugorgane haben etwa die Grösse kräftiger Stabbacterien, dringen nur bis zur Mitte oder bis zu Zweidrittel der Zellwanddicke ein, wirken aber trotzdem auf den Zellinhalt tödtend und führen dem Mycel reichliche Nahrung zu, da ohne eine solche Zufuhr die so üppige

Pilzpolsterbildung nicht recht erklärbar sein würde" (Hedwigia **27**: 15. 1888). Subsequent writers seem to have shared in this opinion and Tubeuf figures these so-called haustoria in the case of both Herpotrichia and Trichosphaeria (Pflanzenkrankheiten, figs. 84 and 82). Hartig himself is surprised that haustoria which do not pierce the cell wall should, nevertheless, be able to destroy the cell contents, and his argument that the abundant development of the mycelium can not be accounted for other than by the presence of these "haustoria" seems to me futile in view of the fact that the mycelium permeates the leaf tissues throughout and causes much more profound changes in the cells of the mesophyll than in those of the epidermis (pl. XIII, fig. 9). Moreover, the fact that the mycelium separates with the utmost ease from the substratum (in making free-hand sections it is almost never that the mycelium remains in contact with the epidermal cells), and the further fact that hyphae carefully separated from the leaf surface show neither haustoria nor any trace of them, seem to militate against Hartig's theory. My opinion is that what this observer took to be haustoria are cracks produced in the very thick external walls of the epidermal cells by the killing and subsequent drying-out effects brought about by the dense mycelium. In any case this fungus affords a striking example of the destructive effects of combined epiphytism and parasitism.

The following description is compiled from American specimens.

Herpotrichia nigra (Pk.) Sacc. Perithecia spherical with slightly prominent ostiola, 0.25 to 0.45 mm. diameter, semi-immersed in a dark brown, felt-like subiculum 0.27 to 0.5 mm. thick. Asci club-shaped, 128 to 155μ by 14 to 18μ. Paraphyses filiform, fugacious. Ascospores irregularly biseriate in the asci, elliptical, at first 1 to 3-septate, hyaline; later 3-septate, more or less constricted at the septa, pale to darker olivaceous-brown, 22 to 33μ by 8.5 to 9μ. Conidia borne singly on short hyphae, dark brown, 3 to 6-septate, constricted at the septa, 27.5 to 29μ by 9 to 10μ.

Habitat. On living leaves and twigs of *Picea excelsa*, *Pinus montana*, *Juniperus communis* and *Juniperus nana* (Europe); *Picea Engelmanni*, *Abies lasiocarpa* and *Abies concolor* (Wyoming, Colorado and Oregon).

Synonym. *Enchnosphaeria nigra* (Hartig) Berl.

Exsiccati. Rehm, Asco. Exsicc., No. 996; Allescher & Schnabel, Fung. Bavar., No. 70; Rabenhorst, Fung Eur , No. 3961; Vestergren, Microm. Rar. Sel., No. 600.

NEOPECKIA COULTERI (Pk.) Sacc.

In the introduction to this paper I mentioned the fact that subsequently to the finding of Herpotrichia on Abies and Picea, I secured a further supply, from much the same locality, of what appeared to be the same

fungus on *Pinus Murrayana*. It presented precisely the same dark-brown, broadly spreading, felt-like mycelium, showing similar immersed perithecia, and causing the same killing and matting-together of the leaves (pl. XII, figs. 1–3; pl. XIII, fig. 10).

Microscopic examination of this fungus showed that in every detail it corresponded exactly with *Herpotrichia nigra* except in the case of the spores. Whereas in the Herpotrichia they are more or less biseriate in the asci and, at maturity, 4-celled and olivaceous, in the fungus on Pinus they are strictly uniseriate, 2-celled, and becoming very dark brown as they mature (pl. XIII, figs. 11 and 12). This fungus was originally described by Mr. C. H. Peck under the name *Sphaeria Coulteri* (Hayden, Rep. U. S. Geol. Survey. 1872, p. 792). Eight years later Cooke described, as *Lasiosphaeria acicola*, Cke., a specimen "collected and characterized by Madame Libert, now in the Herbarium of the Botanic Gardens at Brussels." It is noted as occurring "on pine leaves, Rocky Mountains (Dr. Lyall in Herb. Kew)" (Grevillea **8**: 87. 1880). Cooke's description is sufficient to identify this fungus with that previously described by Peck.

Later Saccardo, through some strange misconception, transferred this species to the genus Enchnosphaeria, but adds the query "an potius Eriosphaeria?" (Syll. Fung. **2**: 207. 1883). He was evidently misled by the external resemblance of this American fungus to the common European *Herpotrichia nigra*, the spores of which were originally described as hyaline; then, discovering that the spores of the former were 2-celled, he suggested writing Eriosphaeria for Enchnosphaeria, both of which names are inapplicable. In the previous volume of the Sylloge, however (**1**: 727. 1882), Saccardo had inserted Cooke's *Lasiosphaeria acicola*, but had questioned its proper generic place, writing *Amphisphaeria? acicola* (Cooke) Sacc. The question mark is more than justified; the fungus is certainly not an Amphisphaeria. Finally this same writer (Bull. Torrey Bot. Club **10**: 127. 1883) transfers his *Enchnosphaeria Coulteri* (Pk.) to his new genus Neopeckia and it becomes *N. Coulteri* (Pk.) Sacc. Just why Ellis & Everhart (N. Amer. Pyrenomycetes, p. 147. 1892), re-transferred it to Lasiosphaeria, is not apparent, since their own characterization of that genus—"sporidia hyaline or subhyaline, cylindrical or vermiform"—does not in the least apply to the specimen of the fungus in question, distributed by them (N. Amer. Fung., No. 1342).

This fungus, so closely resembling *Herpotrichia nigra*, appears to be fairly common throughout the mountainous regions of the western and northwestern states. Both fungi are found in the same localities; but whereas the Herpotrichia occurs in this country on Abies and Picea exclusively, so far as is at present known, the Neopeckia appears to be confined to the genus Pinus. My own specimens were collected in September, 1903,

on *Pinus Murrayana*, in the neighborhood of Pacific Creek, Wyoming. The specimen distributed by Ellis & Everhart is labelled merely "on *Pinus contorta*. Rocky Mts., Cal." Two specimens received from Mr. C. L. Shear are from Oregon and Idaho respectively; one is on *Pinus contorta*, the other is marked "on living Pinus." The dates of collection range from July to September, and all of the specimens exhibit fully mature spores.

The following detailed description of the fungus is drawn from the Wyoming specimens:

Neopeckia Coulteri (Pk.) Sacc. Perithecia spherical, 0.32 to 0.5 mm. diameter, immersed, except for the slightly prominent, flattened ostiola, in a dark brown, felt-like subiculum, 0.4 to 0.53 mm. thick. Asci cylindrical, 150 to 185μ by 15 to 18μ. Paraphyses filiform, fugacious. Spores obliquely uniseriate in the asci, blunt-elliptical, at first pale brownish, later dark-brown, 1-septate, constricted at the septum, 20 to 29μ by 9.5 to 10.2μ.

Habitat. On living leaves and twigs of *Pinus Murrayana* and *Pinus contorta* (Wyoming, California, Oregon and Idaho).

Synonyms. Sphaeria Coulteri Peck (1872); *Lasiospheria acicola* Cooke (1880); *Amphisphaeria? acicola* (Cke.) Sacc. (1882); *Enchnosphaeria Coulteri* (Pk.) Sacc. (1883); *Lasiosphaeria Coulteri* (Pk.) Ell. & Ev. (1892).

Exsiccati. Ellis & Everhart, N. A. Fungi, No. 1342.

The damage caused by these two fungi is, according to my limited observation, inconsiderable. In Europe *Herpotrichia nigra* is said to attack seedling conifers, and even to kill them by completely covering them with matted mycelium. In other cases the seedlings, bent over under the weight of snow, become fastened to the ground by the mycelium and only recover with difficulty. In this country, however, the only specimens which I have seen, whether of Herpotrichia or Neopeckia, were on trees of larger growth and the injury was confined to not more than one foot of the ends of branches a few feet from the ground. These portions were killed.

I have considered these two fungi at such length, partly because of the damage which they are undoubtedly capable of causing to conifers either in the seed-bed or later, but chiefly because, notwithstanding their common occurrence, one of them has heretofore been reported only once from the United States and neither has received the attention it deserves from American mycologists. The past history of both, too, appears to have been so confused owing, in a measure, to their extraordinary similarity in external appearance and in structure, that I have thought it advisable to straighten out the confusion as best I might.

COLORADO SCHOOL OF FORESTRY
COLORADO SPRINGS

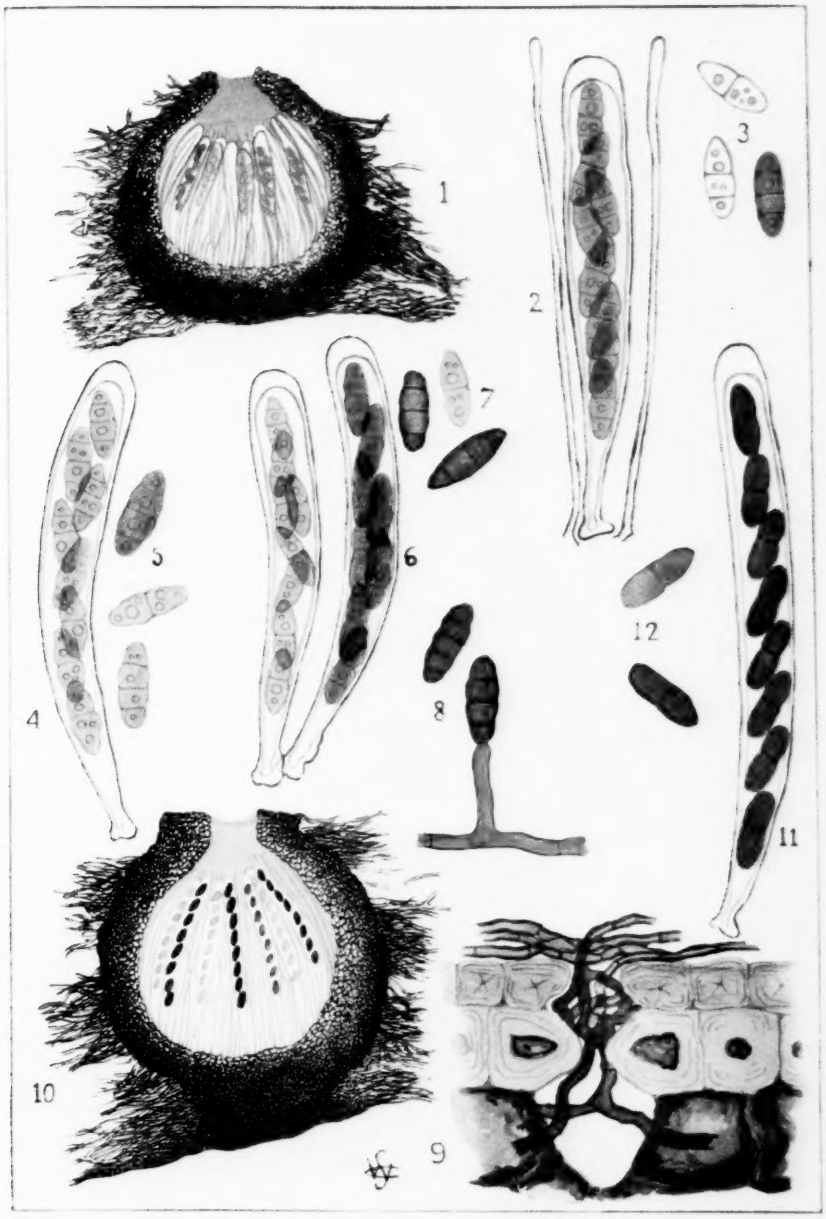
EXPLANATION OF PLATE XII

FIGS. 1–3. Twigs of Pinus Murrayana infested with Neopeckia Coulteri. × ⅓.
FIG. 4. Branch of Abies lasiocarpa infested with Herpotrichia nigra. × ⅓.

EXPLANATION OF PLATE XIII

FIG. 1. Herpotrichia nigra. Section of perithecium. × 100.
Fig. 2. The same. Paraphyses and ascus with immature spores. × 475.
Fig. 3. The same. Two immature spores and one mature. × 475. (Figs. 2 and 3 from specimen in A. & S. Fung. Bav., No. 70.)
FIG. 4. The same. Ascus with immature spores. × 475.
FIG. 5. The same. One immature spore and two mature. × 475. (Figs. 4 and 5 from specimen on Picea.)
FIG. 6. The same. Two asci with spores. × 475.
FIG. 7. The same. One immature spore and two mature. × 475. (Figs. 6 and 7 from specimen on Abies.)
FIG. 8. The same. Hypha and conidia from mycelium on Picea. × 475.
FIG. 9. The same. Mycelium penetrating and filling a stoma. × 475.
FIG. 10. Neopeckia Coulteri. Section of perithecium. × 100.
FIG. 11. The same. Ascus with nearly mature spores. × 475.
FIG. 12. The same. One immature spore and one mature. × 475.

HERPOTRICHIA AND NEOPECKIA ON CONIFERS



HERPOTRICHIA AND NEOPECKIA ON CONIFERS

THE BLACK ROTS OF THE SWEET POTATO[1]

J. J. TAUBENHAUS

WITH PLATES XIV, XV and XVI

THE BLACK ROT. *Sphaeronema fimbriatum* (E.&H.) Sac.

The term black rot of the sweet potato as usually understood by plant pathologists is that disease which is induced by the fungus *Sphaeronema fimbriatum* (E. & H.) Sacc. We owe our past knowledge of this disease to Halsted[2] who in 1890 was first to give us an account of the diseases of the sweet potato. However, Halsted's account of the black rot is incomplete. The disease is characterized by dark greenish circular spots (plate XIV, fig. 3) varying in size from $\frac{1}{2}$ to 2 inches in diameter. These roundish spots are more often met with in infected sweet potatoes in the store house. When the roots are injured through rough handling in cultivation or by rodents, the spots lose their circular outline but follow the line of injury. When the infected root is uninjured, the spots are smooth and appear as if burned in with a metal dye. The pycnidia do not appear for a considerable time after infection, especially when the infected roots are kept under dry conditions. They finally develop on the epidermis (plate XIV, fig. 4) in the center of the spot. None are formed within the infected tissue of the root.

Three years of observation on the black rot in Delaware have shown that the disease does not produce decay of the entire root, as is usually believed, but is confined to the cambium layer. In cases of black rot where the entire root decays, it is due to secondary infections of one or two species of Fusaria or of *Trichoderma köningi* Oud. Cultures of the interior tissue of such infected roots always gave a pure growth of the above fungi but not of the Sphaeronema. If no secondary infection sets in, sweet potato roots attacked by the Sphaeronema alone can remain entire the whole season, the spots gradually spreading over the surface of the root but leaving the interior uninjured. In cases of deep injury or of transverse cuts, the fungus first penetrates the center, then gradually invades the entire root. At the same time, the cut surface is covered with a weft of ashy-colored

[1] Paper read before the American Phytopathological Society at the Cleveland meeting, January 3, 1913.

[2] Halsted, B. D. Some fungus diseases of the sweet potato. N. J. Agr. Exp. Sta. Bul. 76: 7–14. 1890.

mycelium of the Sphaeronema fungus, soon to be followed by the thickly set pycnidia which now cover the entire area. *Sphaeronema fimbriatum* imparts a bitter taste to the affected spot. When such root is cooked for eating purposes the bitter taste permeates the whole root, but if the infected area is first cut out, the edible qualityof the remainder of the root is unimpaired.

Our studies on the morphology of *Sphaeronema fimbriatum* bear out in part those of Halsted and Fairchild.[3] Old mycelium is darkish gray, with rather close septa, and usually filled with oil gluboles when grown on media rich in sugar. The young mycelium is hyaline but becomes grayish with age. The hyphae young or old are capable of breaking up into as many cells as there are septa and each cell germinates like a spore (plate XV, figs. 5 to 8, 10, 12 to 14, 26, 27, 28). Another stage of spore formation corresponds in part to Thielavia, namely, the spores are borne within the sheath of a terminal cell, and these are pushed out from within (plate XV, figs. 15 to 17). There is another spore stage consisting of olive-brown conidia (plate XV, figs. 13, 17 to 22, 28). These are thick-walled, and are borne singly, by twos, or in chains. These brown conidia apparently serve as resting spores, since it takes them a much longer time to germinate. This type of spore is often found in the interior of the affected tissue, in the cells immediately below the epidermis (plate XIV, fig. 4). A last stage is that of pycnospores, which are borne in long-necked pycnidia (plate XIV, fig. 4). The spores are globular, minute, oozing out in a gelatinous mass, and stick at the open end of the long neck of the pycnidium. Any of these spores germinate in water or in any nutritive fluid (plate XV, figs. 1 to 9, 22). No perfect stage has as yet been found and no spore stages other than those above mentioned have been observed, in pure cultures or on the host, to be connected with the *Sphaeronema fimbriatum*.

The pathogenicity of *Sphaeronema fimbriatum* can readily be established by placing the sweet potato roots or potted plants in a moist chamber and spraying them with a suspension of spores of any of the stages of the fungus, or by inserting bits of pure culture mycelium into the tissue of the host. The disease usually develops within two to three weeks after infection, producing the typical black rot symptoms (plate XIV, figs. 2 and 3). A warm moist atmosphere, either in the field or in the store house, furnishes ideal conditions for infection. Occasionally, in a lot of sweet potatoes a few of the roots will remain entirely immune to either artificial or natural infection, indicating, therefore, the possibility of resistant strains. It is also found that the smallest roots are the most resistant; this is probably one reason why sweet potato growers prefer small roots for seed.

[3] Halsted, B. D. and Fairchild, D. G. Sweet potato black rot. Journ. Mycol. **7**: 1–11. 1891.

The spread of the disease in the field is no doubt due to infected roots (seeds) and infected manure. It is usually a common practice among growers to dump all infected roots on the manure pile. The cultivator, as well as field rodents, also help to spread the disease from hill to hill. In storage the disease is introduced on infected roots and then spread by means of mites and the red spider. The two latter when transferred from diseased to healthy roots will communicate the disease to the healthy ones. A pure culture of the fungus can also be obtained when these insects are taken from infected roots and allowed to crawl over a poured plate of culture media (plate XIV, fig. 5).

CHARCOAL ROT OF THE SWEET POTATO. *Sclerotium bataticola* n. sp.

Historical. In describing the morphology of *Sphaeronema fimbriatum* Halsted[4] notes a fourth or sclerotium stage of that fungus. To quote Halsted, "A fourth form of the black rot is sometimes found in which the substance of the potato becomes filled with minute, black, irregular masses. The root thus affected takes on a color that looks like charcoal. A highly magnified view of a small portion of the fungus is seen to consist of black nodules with brown threads running from one to another.

In writing again on the sweet potato black rot, a year later, Halsted and Fairchild[5] seem to be undecided as to whether the sclerotium fungus above mentioned was or was not a stage of the *Sphaeronema fimbriatum*, for they say: "Although not certainly connected with the species of fungus causing the black rot, there have been found, often in badly diseased specimens, immense numbers of globular sclerotia differing in structure from those of many other species, but surrounded by and evidently made up of hyphae identical with these of this species. These sclerotia were found in all stages of formation, and in the last stages in such abundance as to entirely fill the tissue of the diseased potato, causing it to become gray and finally charcoal-black."

Later workers on sweet potato diseases all quote Halsted verbatim, and apparently all accept his statement that the sclerotium fungus is a stage of *Sphaeronema fimbriatum*.

Burnette[6] in discussing the black rot, *Ceratocystis fimbriata*, states among other things that: "After a time the entire root becomes filled with a dark fungus growth, which characteristic gives it the name of black rot. Still further along in its course of development a stage is reached in which the

[4] Loc. cit., pp. 11–18.

[5] Loc. cit., pp. 1–11.

[6] Burnette, F. H. Sweet potatoes. La. Agr. Exp. Sta. Bul. 30 (second series), p. 1088. 1894.

whole inner substance assumes a charcoal-like condition. This is called the sclerotial stage, and seems to be the most common condition in which we find potatoes affected by the disease here."

Townsend[7] in his discussion of the black rot fungus, accepts Halsted's[8] view, as he says: "The threads of the fungus enlarge and turn dark in certain places, forming nodules. Although these bodies are not strictly spores, they perform the same functions as spores."

Wilcox[9] in his description of the black rot, *Ceratocystis fimbriata*, also states: "In addition to these methods of reproduction (conidia and pycnidia, the fungus produces hard dark-colored roundish bodies inside the root known as sclerotia. These are simply compact masses of vegetative filaments of the fungus, but each one of the masses is capable of developing the other stages and spores of the fungus."

Finally, in a recent review of the black rot of the sweet potato, Duggar[10] supports the view of Halsted, for he adds: "When the mycelium has developed to a considerable extent in the root, sclerotia of large size appear. It is believed that these sclerotia may be properly a phase in the life history of this species, and that they may also be important in the perpetuation or spread of the fungus."

There is no doubt that all the authors which I have quoted had in mind Halsted's supposed sclerotium stage of *Sphaeronema fimbriatum*, since all, with the exception of Duggar, reproduced the same figures as Halsted[11] gave in his bulletin on the diseases of the sweet potato. It is surprising that twenty-two years should have elapsed since Halsted gave us the first knowledge of the sweet potato diseases, and that no subsequent worker should have tried to determine definitely whether or not the sclerotium fungus here in question is a stage of *Sphaeronema fimbriatum*. Our own investigations have shown conclusively that it is not, but that it is distinct and in no way related to the Sphaeronema. I have already shown that the black rot only produces spots on the surface of the root which when once seen cannot be mistaken. This disease does not penetrate the root much further than the cambium layer. The sclerotium fungus, on the other hand, does not seem to produce surface spots and it invades the entire contents of the root, turning the substance to a charcoal mass (plate XIV, fig. 10). I propose, therefore, the name of "charcoal rot" for the sclerotium disease.

[7] Townsend, C. O. Some diseases of the sweet potato and how to treat them. Md. Agr. Exp. Sta. Bul. 60. 1899.

[8] Loc. cit.

[9] Wilcox, E. M. Diseases of sweet potatoes in Alabama. Ala. Agr. Exp. Sta. Bul. 135: 6. 1906.

[10] Duggar, B. M. Fungous diseases of plants, p. 349. 1909.

[11] Loc. cit.

With the exception of drying and slight shrinkage, there are no external symptoms to distinguish this disease. It can only be recognized when the roots have been completely invaded by the fungus. Such roots become light and dry and can be readily broken in two. The interior tissue is found to be entirely black and charcoal-like. This blackening is due to the formation within the host of numerous minute sclerotia (plate XIV, fig. 11). A pure culture of the fungus can be readily obtained by aseptically breaking an infected root and picking out bits of tissue with a sterile needle and dropping them into poured plates of nutrient agar. The fungus grows well on media rich in sugar, although it develops equally as well on a variety of other media. With the exception of the sclerotium stage, no other fruiting body of any kind has been observed, either in pure culture or on the host.

Halsted[12] figures a sclerotium bearing dark, roundish spores on slender stalks, resembling the brown olive-shaped spores of *Sphaeronema fimbriatum*. Such spore-bearing sclerotia have often been found by us to be connected with *Sphaeronema fimbriatum* (plate XV, fig. 25). However, these bodies are not really sclerotia, but merely immature pycnidia, since they can be readily crushed under a cover class, whereas the sclerotia of the fungus here in question are hard and resist crushing. Halsted's figure must be hypothetical or else that of a young pycnidium of Sphaeronema.

Pathogenicity. The most severe test as to whether this sclerotium fungus is or is not a stage of Sphaeronema is its pathogenicity. When bits of pure cultures of the sclerotium fungus are inserted into healthy sweet potato roots the typical charcoal disease is induced within three to eight weeks after infection. The fungus can then be reisolated from the artificially infected roots and the disease produced again at will, and each time only the sclerotium fungus is involved. On the other hand, when a pure culture of the Sphaeronema is inoculated into healthy sweet potato roots, the typical black rot disease is induced at will; and at no time has the charcoal disease or the sclerotium mass appeared. This conclusively proves that the charcoal disease, and the sclerotium fungus which induces it, is distinct from the black rot which is induced by the fungus *Sphaeronema fimbriatum*.

Life history. Diseased roots kept dry for one year will readily yield a pure culture of the fungus, thus showing that these diseased roots carry the fungus from year to year. There seems no doubt that the fungus is kept alive and spreads from the store house to the field, and vice versa, through the manure, and possibly with infected roots.

Taxonomy. In identifying sclerotium-producing fungi, one is often at sea, on account of the meagre descriptions of published species. The writer has carefully examined Schweinitz's collection of Sclerotium at

[12] Loc. cit.

the Academy of Natural Sciences in Philadelphia. No species there were found to agree with the one here in question. Moreover, our present species could not be found to correspond with any of the species described and recorded by Saccardo.[13] Several attempts have been made to germinate the sclerotia with the hope of producing a perfect stage. However, it was found that in every attempt the sclerotia would merely produce new sclerotia. Therefore, until a perfect stage or some other spore form is found, the name *Sclerotium bataticola* n. sp. is proposed, with the following description:

Sclerotium bataticola n. sp

Sclerotia jet black, very minute; exterior smooth, made up of anastomosed black hyphae; interior light to dark brown, made up of free, thick-walled, cortical, hyphal cells; sclerotia vary much in shape, spherical, oval, oblong, elliptical, curved or even forked, varying in size from 25 x 22.4 μ to 152 x 32 μ, abundant throughout the entire root of the host.

Parasitic on living roots of sweet potato, *Ipomoea batata*.

JAVA BLACK ROT. *Lasiodiplodia tubericola* E. &. E.

This is a third form of sweet potato black rot.

Historical. The only account we have of the fungus is a short note by Clendenin.[14] The fungus was first found on some sweet potatoes that were brought to the Louisiana Station from Java in the spring of 1894. The potatoes appeared sound, but failed to grow when planted. Upon examination the roots were found to be rotted. The fungus which caused the rot was sent to Ellis, who identified it as a new genus and gave it the name of *Lasiodiplodia tubericola*. Sweet potatoes brought from Java in the spring of 1895 were found to be affected with the same fungus when they were received at Baton Rouge. This seems to indicate that the fungus was introduced from Java to the United States. We do not know how it was introduced into Delaware, where it was first noticed by the writer in 1910 on stored roots.

Symptoms. Sweet potatoes affected by this fungus show dark shrivelled patches, over which are scattered numerous pycnidia. These emit either mature one-septate dark spores of the Lasiodiplodia type, heaped together, or white strings which are made up of hyaline Macrophoma spores, or both. In making longitudinal sections through different stages of affected roots, it will be found that the fungus attacks the interior tissue beginning at a point and gradually invading the whole of the interior of the root (plate

[13] Sylloge Fungorum **14**: 1139–1174; **18**: 690–691.

[14] Clendenin, Ida. Lasiodiplodia E. & E. Bot. Gaz. **21**: 92. 1896.

XIV, fig. 7). The infected tissue is jet black, somewhat resembling the charcoal disease. Infected roots dry and shrivel and become brittle. The name Java black rot is proposed for this disease in order to distinguish it from the other two black rots, and because diseased sweet potatoes suffering from this disease were first introduced from Java.

Pathogenicity. No infection experiments have ever been recorded before with this fungus on the sweet potato. In our investigations we find it to be an active parasite, since the disease can be induced at will either by placing healthy roots in a moist chamber and spraying with a suspension of pycnospores of the Macrophoma or Lasiodiplodia types, or by inserting bits of mycelium from a pure culture of the fungus into the healthy root. In either case complete rotting of the root is effected in four to eight weeks, some roots being more susceptible than others. It seems that the fungus works by means of an enzyme, for in a longitudinal section of a newly infected root two zones can be observed (plate XIV, fig. 7), one, a dark patch, is occupied by the fungus, and the other, a brown zone, precedes the dark patch and is devoid of mycelium. The pycnidia are born singly or in groups under the epidermis (plate XIV, fig. 8), and the latter is ruptured at an early stage. They are also formed throughout the interior tissue of the affected root, and it seems that in this case the spores can only escape when the infected roots break up and disintegrate. The pycnidia when borne free may or may not possess hair-like bristles at the openings of the necks. Also, they may or may not have paraphyses. It was only because of the presence of paraphyses in the pycnidia that Ellis created the genus Lasiodiplodia. More work is now in progress to determine the relationship of this fungus with other Lasiodiplodias and with species of the genus Diplodia. A more extended description of the three black rots will soon be published in bulletin form.

Type material of *Sclerotium bataticola* has been deposited in the herbaria of the Delaware Agricultural Experiment Station, the Departments of Plant Pathology at Cornell University and the University of Wisconsin, the New York Botanical Garden and the National Museum at Washington, D. C.

DELAWARE AGRICULTURAL EXPERIMENT STATION
NEWARK, DELAWARE

EXPLANATION OF PLATE XIV

Figures 1 to 5, Sphaeronema fimbriatum; figures 6 to 9, Lasiodiplodia tubericola; figures 10 and 11, Sclerotium bataticola.

FIG. 1. Healthy sweet potato plant (check).

FIG. 2. Sweet potato plant artificially infected with the black rot organism.

FIG. 3. Black rot of sweet potato as it appears naturally and as a result of artificial infection.

FIG. 4. Photomicrograph of cross-section of an infected sweet potato, showing a pycnidium of the black rot fungus.

FIG. 5. Poured plate of agar with mite taken directly from a root infected with black rot and placed at center. Notice colony of Sphaeronema fimbriatum in center of plate, and two rows of bacterial colonies marking the tracks followed by the mite.

FIG. 6. Surface view of a sweet potato showing early infection of the java black rot. Notice in the central portion of the spot the white strings of Macrophoma spores and the black powder of one-septate Lasiodiplodia spores oozing out from the pycnidia.

FIG. 7. Longitudinal section of potato shown in figure 6.

FIG. 8. Photomicrograph of a cross-section of a sweet potato showing cluster of pycnidia without bristles, formed immediately below the epidermis.

FIG. 9. Photomicrograph of cross-section of sweet potato, showing pycnidia with long necks and bristles, formed immediately below and breaking through the epidermis.

FIG. 10. Cross-section of healthy and diseased roots infected with Sclerotium bataticola.

FIG. 11. Photomicrograph of cross-section of sweet potato to show presence of sclerotia in the host.

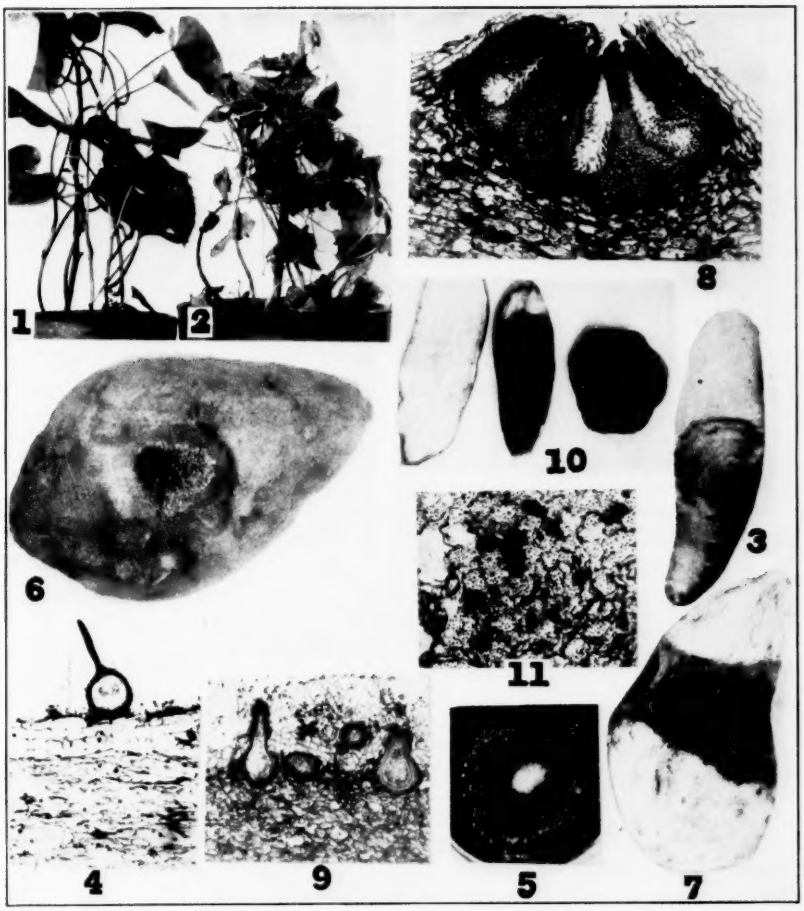


PLATE XIV. BLACK ROTS OF SWEET POTATOES

Explanation of Plate XV

Figures 1 to 28, Sphaeronema fimbriatum; figures 29 to 42, Lasiodiplodia tubericola.

Figs. 1, 9, and 22. Stages in the germination of the brown olive-shaped thick walled conidia.

Figs. 5 to 8, 10, 27 and 28. Different stages in the germination of the hyaline conidia.

Figs. 2 to 4 and 11. Different stages in the germination of the pycnospores.

Figs. 13, 17 to 22 and 28. Different stages in the formation of the brown conidia.

Figs. 12, 13, 14 and 26. Hyphae breaking up into spores.

Figs. 15 to 17. Thielavia-like spore formation.

Fig. 25. Young pycnidium resembling a sclerotium.

Figs. 29 to 37. Different stages of germination of the Lasiodiplodia spores.

Figs. 32 and 36. Striated spore cover. The striations are better visible when the spore germinates.

Figs. 38 to 42. Different stages of germination of the Macrophoma spores of L. tubericola.

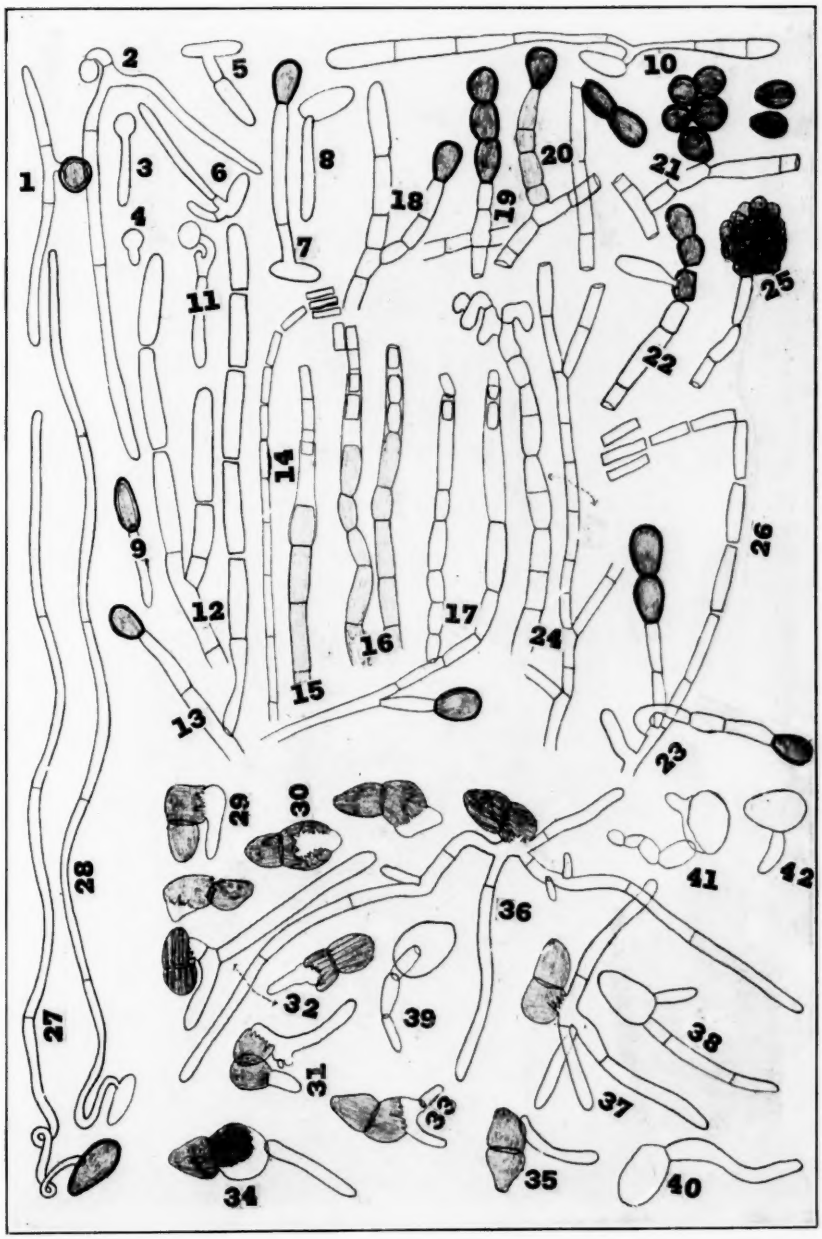


Plate XV. Black Rots of Sweet Potatoes

Explanation of Plate XVI

Figures 43 to 53, Lasiodiplodia tubericola continued; figures 53 to 59, Sclerotium bataticola.

Figs. 47 to 50. Variation of size in the Lasiodiplodia spores.

Fig. 43. Attachment of spores and paraphyses to the inner wall of the pycnidium.

Fig. 44. A single paraphysis.

Fig. 45. Stages of formation of pycnospores.

Fig. 46. Crush mount showing the fungus Sphaeronema fimbriatum to be inter and intracellular. The brown olive-shaped conidia are also born within the host cells.

Figs. 53 to 59. Different stages in the sclerotium formation.

Note.—All drawings are made with the camera lucida.

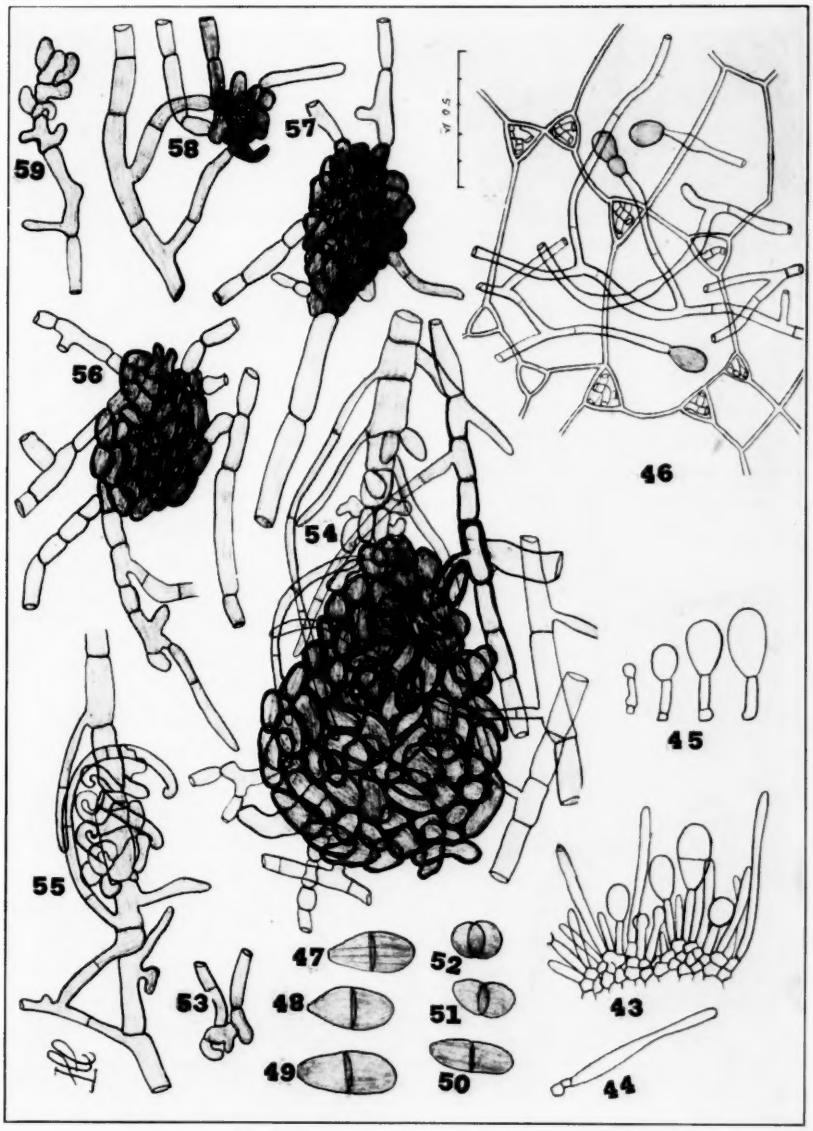


Plate XVI. Black Rots of Sweet Potatoes

NOTES ON CRONARTIUM COLEOSPORIOIDES ARTHUR AND CRONARTIUM FILAMENTOSUM

E. P. Meinecke

In Phytopathology **2**: 176, August, 1912, Dr. George G. Hedgcock reported successful inoculation of two species of Castilleia with aeciospores of *Peridermium filamentosum* Peck and proposed the name *Cronartium filamentosum* (Peck) Hedgcock comb. nov. for the resulting Cronartium. Dr. Hedgcock proposed the new name on account of my successful inoculation of *Castilleia miniata* with *Peridermium stalactiforme* Arthur and Kern, which established the relationship of the latter species of Peridermium with *Cronartium coleosporioides* (Dietel and Holway) Arthur, and for the further reason that Dr. Arthur has considered the two forms of Peridermium to be morphologically different and has raised them to specific rank, thus rendering the identity of the two species of Cronartium uncertain, although they appear to be morphologically identical.

On September 16, 1911, I had found *Cronartium coleosporioides* very plentiful on *Castilleia miniata* in the immediate neighborhood of aecia of *Peridermium stalactiforme* in the Lassen national forest, California.[1] This fact, together with Dr. Hedgcock's early conjecture (July, 1911) that *Peridermium filamentosum* formed its Cronartium on Castilleia, led me to try inoculation with *Peridermium stalactiforme*. *Pinus contorta* in the neighborhood of Fort Klamath, Oregon was found to be richly infected with this Peridermium, and at the end of May, 1912, when the aecia were just opening and some of them discharging spores, specimens were collected for use in inoculation. In the same locality, and on the same day, squares of sod each containing about six to eight young plants of *Castilleia miniata* were cut out. These squares were immediately packed in the field and carefully guarded from any possible contamination from the Peridermium material. On the following day all the material was taken to Odessa, Oregon, 25 miles away, where no *Peridermium stalactiforme* is found. At Odessa one of the squares was richly dusted with aeciospores of *Peridermium stalactiforme*. The inoculated and the uninoculated material was then transferred to the botanical garden of the University of California at Berkeley and kept in separate houses.

Inspection on June 18 showed the Cronartium stage plentifully developed

[1] Mycologia **4**: 142. May 1912.

on the older leaves of the inoculated Castilleia plants. There were some uredospores present. The teliospores showed signs of germination. On June 20 many rather larger sporidia had been formed. The check material was free from Cronartium and remained healthy.

OFFICE OF INVESTIGATIONS IN FOREST PATHOLOGY
UNITED STATES DEPARTMENT OF AGRICULTURE
SAN FRANCISCO, CALIFORNIA

A BACTERIAL ROT OF CUCUMBERS

O. F. Burger

The cucumber crop of Florida has been seriously injured during the las two years by a bacterial disease of the leaves and fruit. Brown spots which may fuse into large brown patches appear on the leaves. On the fruit watery spots with brown centers are seen, and later the cucumbers become soft and translucent throughout. The first signs of infection on the leaves are watery spots. In the early morning a drop of bacterial ooze is to be found on the under side of the leaf on the water-soaked spot. Later in the day the ooze dries, leaving a white residue. The spots turn brown, and when old drop out of the leaf.

The first spots on the fruit are from 1 to 2 mm. across, and have, as has been stated, a water-soaked appearance. Each has a darker center formed of dead epidermal cells, and appearing as if some insect had punctured the fruit there. The spot does not spread laterally on the surface, but the subepidermal tissue turns brown. The infection reaches the vascular system, and then spreads quickly, softening and browning the tissues as it advances. Finally the whole cucumber is reduced to a soft watery mass. The cucumber grower pays little attention to small spots on the fruit, and thus diseased cucumbers are often packed with good ones, with the result that on arrival at the market the baskets may be "leaking." It takes from three to four days for the shipment to reach the market, and in this time much of the infected fruit becomes soft.

Cultures were made from a young spot by cutting small pieces from under the epidermis with a sterile knife and dropping them into tubes of beef bouillon. In twenty four hours the bouillon was cloudy with a bacterial growth. The culture was brushed on a cucumber with a camel's hair brush, and the fruit was then wrapped with paraffined paper. The characteristic spotting appeared. The organism was isolated from this inoculated fruit, and pure cultures transferred to tubes of beef bouillon. These cultures were then brushed on cucumber leaves, and the characteristic leaf spotting appeared. Infected cucumber leaves were brought in from the field and pinned to healthy leaves; the characteristic spots appeared on the healthy leaves. No infection occurred in check plants.

The cucumber growers complained in some cases that the vines were not setting fruit. The ovaries of the flowers were yellowing and drying up. Pure cultures of the bacterium were inoculated into healthy female flowers.

The ovaries after the inoculation did not develop any further, but turned yellow, blackened and dried up.

Microscopical examinations of the spots on the leaves and fruit always showed abundance of motile bacteria. Portions of diseased leaves and fruit were killed in chrom-acetic acid (medium strength), embedded in paraffin, sectioned and stained with iron-alum hæmatoxylin. In all cases bacteria were found to be present in the tissue.

The bacteria grown in standard agar (reaction + 1.5 %) at 30°C. and stained with gentian violet, showed as short rods 1.5 to 2 microns long and 1 micron wide, the majority being 2 microns long. Stained by Hugh Williams' method they showed three to six polar flagella, the majority having only three. Ribbets' method showed the presence of a capsule. The bacteria are not stained by Gram's method. Spores have not been found.

Stroke cultures on regular beef agar (reaction + 1.5 %) are scanty, filiform, flat, glistening, verrucose, opalescent, and slimy. In agar stab cultures, growth is best at top, villous in line of puncture. Gelatin stab cultures show best growth at top, villous in line of puncture. Gelatin is not liquified. A membrane is formed on nutrient broth; strong cloudiness; compact sediment. Milk coagulates slowly; extrusion of the whey began in seven days. Agar colonies are round to ameboid, smooth, convex, and amorphous. There was no gas formed in fermentation tubes; growth occurred in the closed arm. To test tubes containing 10 cc. of milk 1 cc. of methylene blue was added; these were bleached in four days by the organism. In beef boullion with 2 per cent glycerine or 2 per cent saccharose, there is fluorescence. No indol is produced. Nitrates were not reduced. Starch was digested.

The cultural characteristics of this Pseudomonas are being further investigated together with field control methods.

FLORIDA AGRICULTUAL EXPERIMENT STATION
GAINESVILLE, FLORIDA

A BOTRYTIS DISEASE OF DAHLIAS[1]

MEL. T. COOK AND C. A. SCHWARZE

WITH PLATE XVII

During the past year our attention was called to a root rot of dahlias in storage. It was reported as quite severe by one grower, others considered it of little or no importance, while many had not been troubled with it and did not know anything about it. It was most severe on the Sylvia, a decorative variety, and on Kriemhilde, a cactus variety. In only one case was it reported as giving trouble in the field, and the writer did not see that case. This single field record was for the Sampson variety.

The diseased roots have a watery appearance, the interior is soft and wet, becoming yellow, brownish and finally black. The determination of the cause of this disease was complicated by the presence of a number of other organisms which contributed to the rot when it was once started by the primary factor. This primary factor was finally found to be a grayish or brownish Botrytis.

The disease appeared to be most severe under warm, moist conditions, combined with poor ventilation. However, roots buried in pits for the winter with no ventilation and considerable moisture were in perfect condition. Many inoculation experiments indicate that the organism is unable to gain entrance to the host except through wounds. Pure cultures of the organism applied to the clean, sound surface of roots failed to produce the rot, while inoculation from the same cultures on cut surfaces produced the disease very readily.

The organism is a typical Botrytis, growing well on almost any medium and producing an abundance of conidia and, later, an abundance of sclerotia which are variable in size some of them attaining as much as 11 mm. in diameter. The sclerotia are less abundant on the roots and much smaller. This organism has been under observation for the past year and has been grown in a number of different media, but thus far it has not produced a perfect stage.

The mycelium is septate and branched (fig. 1), the conidiophores are of the *B. cinerea* type (fig. 2) and the spores are elongated, measuring from 11.25 to 15 microns in length, averaging 13.43 microns. In germination

[1] Read before the American Phytopathological Society at Cleveland, Ohio, January 2, 1913.

the spores become spherical and send out one, two or three germ tubes (fig. 4) which soon become septate and branched and form peculiar structures (fig. 5) similar to, and possibly the same as, the organs of attachment described by Smith (2). However, a careful study of these organs in hanging drop cultures indicated that they were in reality the incipient sclerotia (figs. 6 to 11). It was possible to trace a complete series, beginning with the formation of these structures and ending with well defined sclerotia. The first stage in their development is the formation of many irregular, short branches, many septa, and an irregular, clubby or knotty appearance. It was also apparent that a sclerotium might be formed from a single mycelium (fig. 9), or that a considerable number might be involved (figs. 10 and 11).

The study of the germination of the spores in drop cultures also showed a tendency for the mycelial branches to unite, whether they came from the same or different spores (figs. 12 *a*, *b*; 13 *a* to *i*). In fact it appeared very evident that when two young mycelial tubes approached within a short distance of each other, they formed a direct union or joined, by means of short mycelial growths. This peculiar attractive force also frequently resulted in the formation of two short lateral tubes from a single mycelium uniting with the tip of an approaching mycelium. This union of mycelia has been observed by Ward (4) who called attention to its similarity to conjugation in various other fungi, and also to the fact that the influence seemed to be the same as that resulting from the conjugation of zoospores among the thallophytes and of sex cells in the archegoniates. He attributed this conjugation to an enzyme activity. Smith (2) figures a union of mycelia, but makes no comment on it; he also figures branching structures similar to those described in this paper but does not show any relationship to sclerotial formation. Price (1) also figures organs of attachment and his figure 8 indicates a possible union of mycelial growths.

Spore plantings were made at definite points in petri dishes and allowed to grow until the mycelial growths came in contact, when it was readily seen that the sclerotia were much more abundant along the intersecting lines than at other points. The mycelia composing the sclerotia are very irregular and septate (fig. 14).

SUMMARY

1. The dahlia root rot is caused by a species of Botrytis, corresponding very closely to the description of *B. cinerea* (Syn., *B. vulgaris*).

2. The infections are always through wounds; it is impossible for them to occur through the uninjured epidermal covering.

3. The young mycelia tend to unite or conjugate by means of short mycelial tubes which usually come out at right angles. In order that this

union may occur, the mycelia must be young and at a distance not to exceed 10 microns.

4. Growths similar to, or the same, as those described by other writers as "hold fasts" always developed into sclerotia.

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NEW JERSEY AGRICULTURAL EXPERIMENT STATION
NEW BRUNSWICK, NEW JERSEY

EXPLANATION OF PLATE XVII

FIG. 1. Fragment of mycelium.
FIG. 2. Conidiophores.
FIG. 3. Conidiospores.
FIG. 4. Germinating spores.
FIGS. 5–9. Stages of branched mycelium in formation of sclerotium.
FIG. 10. Young sclerotium.
FIG. 11. Later stage of sclerotium.
FIGS. 12 a, 12 b. Union of mycelia from two spores.
FIG. 13, a–m. Union of mycelia.
FIG. 14. Fragments of mycelia from sclerotia.
(Figures 3 and 12*b* were drawn with No. 2 ocular and $\frac{1}{12}$ oil immersion; all others with No. 2 ocular and $\frac{1}{6}$ dry objective).

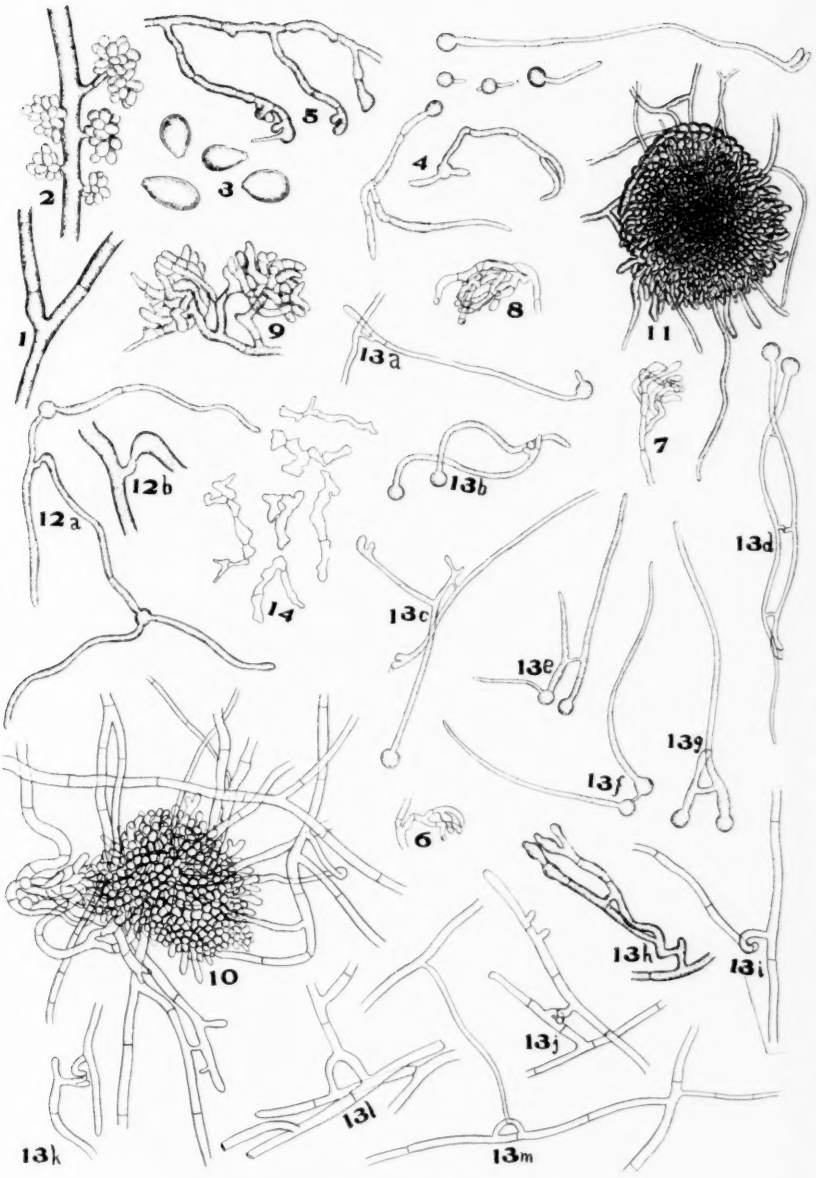

PLATE XVII. BOTRYTIS DISEASE OF DAHLIAS

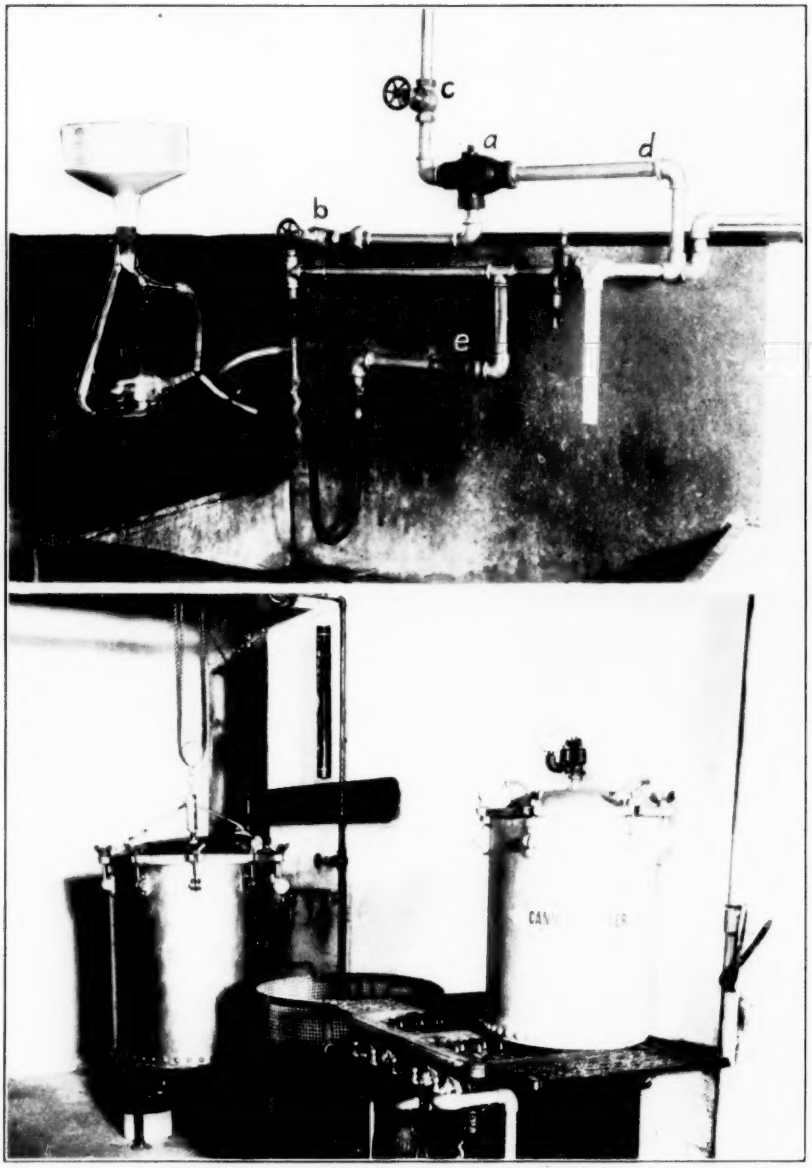

Plate XVIII. Laboratory Equipment

SOME BORROWED IDEAS IN LABORATORY EQUIPMENT

W. J. Morse

With Plate XVIII

In connection with the plant pathology laboratory of the Maine Agricultural Experiment Station there is a basement room which is fitted up for dish washing, sterilization, etc. In this room we have in use certain devices and pieces of apparatus which are either homemade or are adaptations of articles designed to be used for other purposes. Several of these result in the saving of much time and labor and are a constant source of satisfaction to all concerned. The following descriptions are given of some of these, with the idea that they may be of possible service to others engaged in similar lines of work.

Figure 1 represents some attachments connected with the dish washing sink, including a water heating device, an apparatus for rapid and thorough rinsing of test tubes, flasks and other glassware, and illustrates our method for rapid filtration of liquid culture media by suction. Figure 2 shows an inexpensive, portable autoclave and a much larger one of the same type, permanently connected with the steam service pipes and used for soil sterilization.

Water-heating device. Comparing the cost of installation and utility this is perhaps the most satisfactory piece of apparatus in the lot. The essential part of it is the suction-tee shown at *a*. A suction-tee is a fitting in common use among steam fitters and is constructed on practically the same lines as the common filter pump. It is designed for elevating liquids short distances by means of steam pressure and is frequently employed for pumping bilge water from the holds of small steamboats. The present use is an adaption.

For water heating the cold water is introduced into one side from below, the supply being controlled by the valve *b*. The steam supply is regulated by valve *c*, and enters the suction-tee at the left. The hot water emerges at the other end into the discharge pipe *d*. The horizontal part of this pipe which connects with the suction-tee is $9\frac{1}{2}$ inches between fittings. The lower part of the discharge pipe swings back against the wall when not in use.

The entire cost of this water heater including labor and materials for installing was only a little over $3. The low cost was partly due to the

fact that water connections were already in the sink and the steam supply was obtained by tapping a pipe which ran directly overhead. By its use a ½-inch stream of almost boiling water can be obtained instantly and maintained as long as desired. By simply adjusting the valves the temperature of the water can be raised to any degree desired from that of the service pipes up to 85 or 90°C.

If installed in the manner illustrated there is no pounding in the pipes when the steam and cold water come together, and very little noise can be heard when the heater is in use—certainly nothing which would be objectionable in any laboratory. Both high and low pressure steam can be turned into our supply pipe and we have used from 3 to 20 pounds with equal success. With the lowest pressure steam the cold water supply must be reduced somewhat but even then the supply of hot water obtained is ample. In use the steam valve must always be opened last and closed first.

Test tube rinser. This is an adaptation of the method employed in washing and rinsing bottles in bottling establishments and in rinsing drinking glasses at soda fountains. It has been found invaluable as a time saver in washing and rinsing test tubes which have contained cultures. Moreover the rinsing can be much more thoroughly done in this way than in any other that the writer has seen in use. It is simply a small brass tube bent in the form of a broad U. One end is connected with the water pipe and the other or open end points directly upward. In use the operator, holding the article to be rinsed in his left hand, places it over the open end of the pipe and with his right hand turns on the water at the valve *e*. The connection is made to the water pipe by a small brass union which has a ground joint and which allows the tube to swing with the attached arm of the U as an axis. Hence this also may be turned back against the wall of the sink when not in use.

Filtering apparatus. This is largely self-explanatory as shown at the left in figure 1. It consists of a 2-liter flask and a Buchner funnel attached to a filter pump. The funnel is about 17 cm. across the bottom and holds approximately a liter and a half. By placing a circular filter paper flat on the perforated bottom of the funnel and then applying suction, liquid culture media may be filtered much more rapidly than by ordinary methods. It is first necessary to run a small quantity of distilled water through the funnel to wet the paper and just as the last of it is passing through the paper should be pressed down with the fingers at the edges to stop possible leakage. If agar or gelatin are to be filtered a quantity of boiling water should be run through first, to thoroughly heat up both flask and funnel. A large dinner plate is sometimes put over the funnel for a cover, after first dipping it in boiling water. This helps to retain the heat in the case of slow filtering agar. Also in filtering gelatin and agar it is best to remove the

major portion of the coarser particles by first passing through a cotton filter.

Portable autoclave. This is a "home canning boiler" which with safety-valve and steam gage retails for about $15. It is made of boiler iron, 17 inches high and 12½ inches in diameter inside. It is built on the lines of the old style autoclaves and is designed to be used in the home on the kitchen stove. Hence it is well adapted for use in temporary field laboratories or in secondary schools or other institutions where the cost of the ordinary form of autoclave would be prohibitive.

Soil sterilizer. Some form of soil sterilizer is absolutely essential for carrying on work in plant pathology where inoculation studies are made in the greenhouse. It is necessary, if for no other purpose than to prevent the spread of new or rare diseases by means of discarded potting soil. The large autoclave shown at the rear in figure 2 is one of the larger (factory size) boiler-iron canning retorts put out by the same concern which makes the portable canning boiler. This is 30 inches high and 24 inches in diameter inside. Six 10-inch or twelve 9-inch pots of soil can be sterilized in it at one time.

This sterilizer is provided with a steam gage, safety-valve, air cock, and thermometer. The wire basket, standing next beyond the gas range, may be placed within the sterilizer as a container of the articles to be processed, if desired. The cover is of cast iron and quite heavy. A patent pulley block which automatically locks and holds the load at any height, at the will of the operator, was purchased and attached to the cover by means of iron hooks inserted in the handles. By this means the cover can be raised and lowered easily, or suspended, as desired.

MAINE AGRICULTURAL EXPERIMENT STATION
ORONO, MAINE

THE BARBERRY AND ITS RELATION TO BLACK RUST OF GRAIN

H. T. Güssow

Many years before the distinguished mycologist, Anton de Bary, of the University of Strassburg had shown by scientific investigation (in 1865) that the barberry (*Berberis vulgaris* L.) played an important rôle in the spreading of black rust of grain (*Puccinia graminis*), practical farmers on the continent of Europe were convinced that the rust specks on the barberry had some connection with the grain rust. Naturally, the interpretations of this observation were mainly fantastic. Within recent years, and as the knowledge of the life history of these destructive grain parasites advanced, the fact that barberry rust and grain rust were closely related became more and more established. It was clearly proven that the barberry served as an intermediate host for the fungus on grain. However, there has been entertained considerable doubt or lack of appreciation as to the correctness or practical use of this observation, which was regarded as mere theory. It was pointed out by several investigators that in certain districts of Hungary and Sweden very few barberry bushes existed, and still black rust seemed to persist. Dr. Barclay, a famous mycologist of India, cited a particularly interesting example, referring to the grain growing district of the East Indies where there is no barberry to be found within 300 miles of that area. However, beyond this distance in the mountainous regions there were barberry bushes growing. We may note that although in these cases "there were hardly any barberries left" or "they were 300 miles way from a grain growing district" yet there certainly existed some barberries all the time. One of the first European countries which took the matter seriously was Denmark. By means of a legislative act this country enforced the systematic destruction of the barberry. It has been stated by Dr. Lindau in 1908, that notwithstanding the destruction of the barberry, black rust of grain continued its devastations, although the intensity of infection varied to some extent. This latter observation, of course, may be commonly made any one year, the rust varying considerably according to districts or climatic conditions.

In the report of the Dominion Botanist of Canada for 1911, p. 239, the present status of our knowledge of rusts was briefly summarized, and it was stated that it had been found in Denmark, for instance, that the compulsory destruction of barberry has not brought a reduction in the severity

of rusts. This statement was eventually read in Denmark, and we are indebted to Dr. J. Lind of the Phytopathological Experimental Station, Lyngby, Denmark, for a letter in which he refers to this statement explaining that "*Puccinia graminis* is quite perceptibly disappearing in Denmark year by year to the same degree as we get rid of the Berberis, and we are very well satisfied with the results of the Berberis Act."

This communication contained important information of a more definite character than any we have been able to secure previously. We thought it, however, desirable to seek the opinion of another Danish plant pathologist and communicated with Dr. F. Kölpin Ravn of the Pathological Museum of Kopenhagen. He very courteously writes us under March 26: "In your letter of February 27 you desire to know what my personal experience has been concerning the extermination of barberry bushes in this country. I have been able very often to observe early outbreaks of *Puccinia graminis* on rye and oats; in all such cases—without any exception—we have been able to find some barberry bushes near by; and some years after the removal of these bushes these early outbreaks of rust had disappeared.

Several of the Local Advisers in Plant Culture carried on a systematic fight against the barberry bushes, as required under the Act. And at present the early—and only dangerous—outbreaks of black rust are rarely reported. I may add that the farmers have practiced for some recent years sowing spring grain earlier than before, which further helps in the fight against the rust. I think, therefore, that the present very slight infections by *Puccinia graminis* are the results of the two named factors taken together."

From these two letters it would appear that the systematic destruction of the barberry *Berberis vulgaris*, green and purple-leaved,—for the aecidia of the rust fungus occur on both—would produce a very desirable effect, i.e., the checking of the severity at any rate, of that most dangerous rust of grain culture.

The barberry shrub, it must be realized, is worthless as compared with the immense value of cultivated grain. In order to protect the grain industry as much as possible the destruction of the barberry wherever it grows is strongly advocated.

DIVISION OF BOTANY
DEPARTMENT OF AGRICULTURE
EXPERIMENTAL FARM, OTTAWA

BLACK HEART OF POTATOES

E. T. Bartholomew

With Plate XIX

Within the past two years the Department of Plant Pathology of the University of Wisconsin has received several samples of potatoes (*Solanum tuberosum*), showing a blackening of the tissues, especially in the central regions. The term "black heart" has been suggested as most suitable for the description of this abnormality. These samples came from widely distant points but in all cases were taken from carload shipments of potatoes, either while they were in transit or soon after they had reached their destinations. The first report came to Prof. L. R. Jones from Dr. W. J. Morse, of the Maine Experiment Station, who sent a photograph in the winter of 1911, showing this condition in potatoes that had been shipped from Maine to Virginia. In recent correspondence on the subject Dr. Morse says that the trouble was first brought to his attention from Virginia shipments in 1910 by Mr. W. A. Orton, and adds that several Maine potato shippers with whom he has talked report that in their experience the condition is likely to occur where potatoes are overheated in transit.

Specimens were received from a leading produce company of Kansas City, Missouri, in February, 1912, who reported the trouble in three carloads of potatoes just received from Wisconsin which they suspected had been chilled or overheated in transit. In February and March, 1913, similar samples were received from one of the large wholesale potato dealers of Chicago, taken in each case from car shipments upon arrival in Chicago. Professor Jones arranged to have this company advise him promptly upon the arrival of another such shipment that detailed examination might be made and further data secured. Notice was received on March 3 and H. E. Dibble, being especially interested in potato diseases, went to Chicago to investigate conditions. He found that the trouble had occurred in a carload of potatoes just received from northern Wisconsin. These were supposed to be normal before shipping. They had been four days in transit, shipped in a refrigerator car which in order to prevent the potatoes from freezing had been heated with a wood stove. The potatoes, which were in sacks, filled the car, except for a narrow space in the center occupied by the stove. The method of "firing" is to build a hot fire in the stove when the car is started, then close the door tightly and leave it as

long as seems safe from frost, when the fire is again started. In this way the car had been "fired" probably three or four times in transit. Upon opening in Chicago the temperature was still high, perhaps 25°C. Evidences of the extremes of temperature that had occurred during transit were found in the fact that while some of the potatoes in the ends of the car were frosted, those taken from the sacks nearest the stove were baked as nicely as if from a kitchen oven.

Examination of the blackened tissues in both 1911 and 1912 showed them to be sterile and the evidence from Kansas City and Chicago agreed with that from Dr. Morse in indicating that temperature conditions, either alone or in combination with the atmospheric composition, were responsible for the trouble.

The writer, being especially interested in physiological problems, undertook to supplement Mr. Dibble's observations by laboratory treatment of tubers with the aim of producing black heart artificially. Experiments previously conducted by Mr. Dibble had shown that chilling did not induce the typical trouble. The writer, therefore, tried heating at various temperatures both in ordinary atmosphere and in other gases.

The artificial production of black heart in potatoes under laboratory conditions was not found to be a difficult task. The abnormality was produced when potatoes taken in April and May from the storage cellars were exposed to a temperature of about 38° to 45°C. in an ordinary drying oven for from eighteen to forty-eight hours, depending somewhat on the size and variety of the potatoes. Ten different varieties have been tried and each responds more or less readily to the test. So far, it is not evident that the presence of an excess of either oxygen or carbon dioxid influences the physiological changes which occur in the potato while being heated. Nor is the chilling, such as that to which the potatoes were exposed while in transit, necessary to bring about discoloration, for the potatoes used for experimentation in the laboratory were taken directly from the storage cellar, and exposed to the above temperatures. On the other hand, experiments show that the chilling tends to retard rather than to accelerate the physiological changes producing the abnormalities.

The blackening does not develop to the same extent in all potatoes. Apparently the change begins in the center and radiates toward the margin (see pl. XIX, figs. 5 and 6). In some cases, however, half or even more of the central portion of the potato is blackened with no radiations (figs. 1 and 2). It is usually impossible to tell, before cutting open, whether or not the potato is normal since the discolorations, except in extreme cases, do not extend to the epidermis, and the eyes are not killed. If the abnormal potatoes are allowed to remain from ten days to two weeks before cutting open, the blackened tissues in the center shrink, leaving a hollow

with a black lining (figs. 3 and 4). The discoloration is black and entirely different in appearance and distribution from the malady variously known as "internal brown rot," "sprain" and "Eisenfleckigkeit." Nor should this trouble be confused with ordinary "hollow heart."

The degree of success accompanying the laboratory experiments can be shown best by figs. 2, 3 and 5, pl. XIX. These should be compared with figures 1, 4 and 6, which are photographs of potatoes taken from the refrigerator cars mentioned above. The black heart induced in the laboratory is thus apparently identical in every respect with the cases developed in the car shipments.

The evidence at hand leads us to believe that this trouble is not at all uncommon. No doubt other shipping parties have encountered the trouble without reporting it and it is not at all improbable that black heart may be developed in potatoes which are stored in such places as warm cellars and in pits covered with manure.

Further particulars concerning the production of black heart artificially and the physiological changes which cause the blackening and finally the shrivelling of the affected tissues will be treated in a future article. For the present, however, it is important to note that black heart may be produced in potatoes that have been stored during the winter by keeping them for a certain period of time in a temperature of about 40°C.

UNIVERSITY OF WISCONSIN

PLATE XIX. BLACK HEART OF POTATOES

FIGS. 1, 4 and 6 were from car shipments; 2, 3 and 5 were produced by heating in the laboratory oven. The cavities shown in 3 and 4 are secondary developments following the death of the tissues.

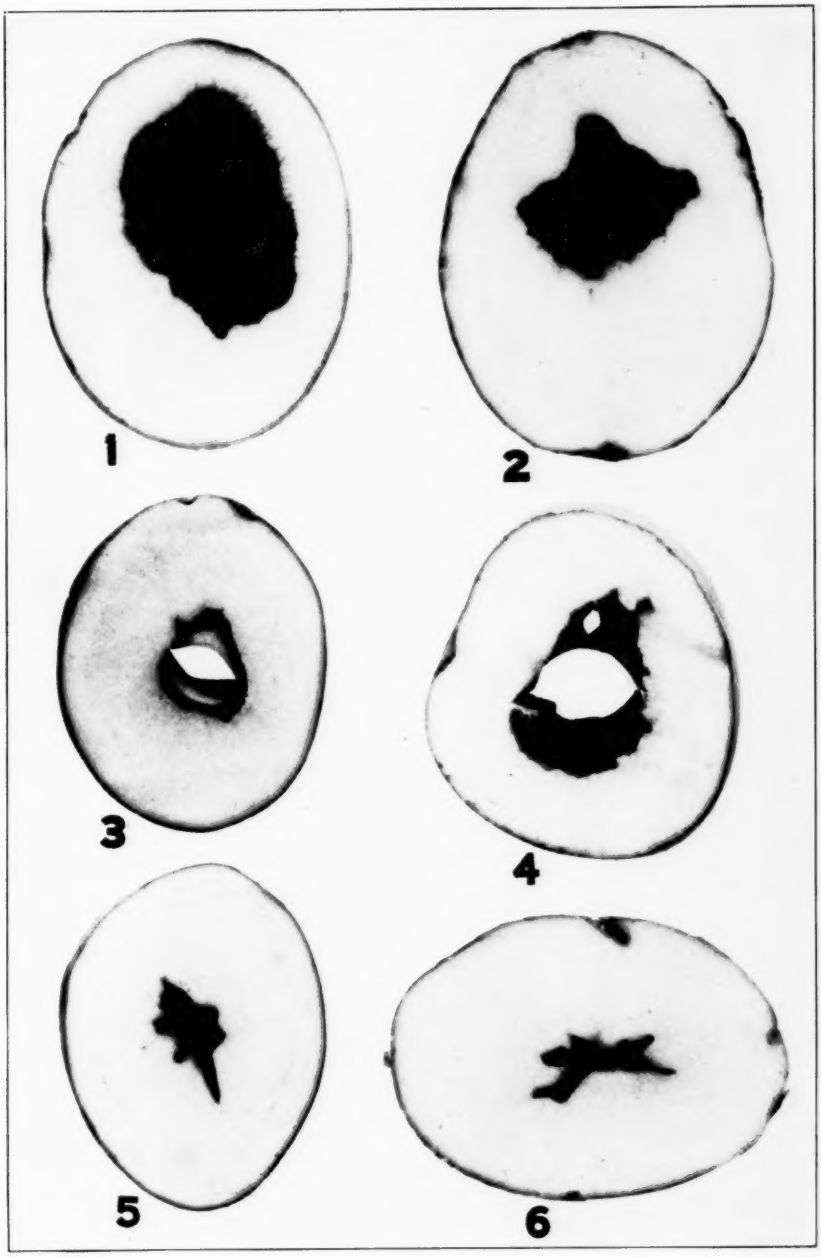

PLATE XIX. BLACK HEART OF POTATOES

FUSARIUM OR VERTICILLIUM ON OKRA IN NORTH CAROLINA?

GUY WEST WILSON

In a recent article Doctor Wollenweber[1] refers to a short paper by Stevens and Wilson[2] on okra wilt, saying that they found "black sclerotia in pure cultures of the parasite, which they call *F. vasinfectum*. To judge from this and my positive results obtained with Verticillium on okra, they may have worked with *Verticillium albo-atrum* and not with a Fusarium." This refers to the statement, "Perhaps the most interesting feature developed in the cultures was the uniform presence of numerous black sclerotia-like bodies similar in structure to those described by Appel and Wollenweber for *F. solani* and related species. These appear to be of the nature of sporodochia, as they are associated with conidia production."

In making the assumption which he does Doctor Wollenweber is inconsistent with a fundamental dictum which he announces earlier in his paper, when he says, "We need, therefore, a pure culture method which gives the normal stages and, if possible, all stages, of a fungus." Students of Fusarium and related forms have reached the conclusion that agar media do not meet this requirement, as numerous abnormalities often develop in cultures on such media, yet he takes the results obtained by cultures on agar and compares them directly with those obtained by culture methods which experience has shown are much better suited to bring out the normal development of the fungus.

Since the article, of which the present writer is one of the authors, is not over detailed and explicit on certain points, and, from the above, evidently open to misinterpretation, a more complete statement concerning this disease appears not inappropriate, especially in view of the importance of the class of diseases of which it is an example.

During the season when the study was made okra wilt was not uncommon arōund Raleigh, and a few wilted plants were noted in the succeeding year. As other fusarial wilts are not uncommon in the state their relation-

[1] Wollenweber. Studies on the Fusarium problem. Phytopathology **3**: 24–50. 1913.

[2] Stevens & Wilson. Okra wilt (fusariose), Fusarium vasinfectum. North Carolina Agr. Exp. Sta. Ann. Rept. **24**: 70–73. 1912.

ship to each other has naturally been kept in view by the station workers who have come in contact with them.

The disease was studied, not primarily from the morphological standpoint, but more especially for the identification of the causal organism. These studies were made by means of moist chamber cultures on okra stems, and pure cultures of the fungus on pea agar. In neither case did the fungus agree with the characterization of *Verticillium albo-atrum*, as it formed sporodochia with conidia which were falcate and usually 3-septate, never unicellular and ellipsoid. So far as observed the "sclerotia-like bodies" upon which Doctor Wollenweber bases his conclusion as to the identity of the North Carolina fungus never occurred on okra stems either in the field or in cultures, but were confined to the fungus when grown on agar. They began by the formation of a single enlarged, dark-colored cell in the vegetative mycelium. In the course of a few days a mass, easily visible to the unaided eye as a black speck, had developed from the cell. Cultures might contain only completely formed bodies, or they might be present in other cultures in all stages of development. Without awaiting a period of rest these bodies immediately developed conidiophores and conidia in the same manner and of the same form as those which developed on the okra stems. It would appear, then, that these bodies were not sclerotia, but stromata, which, according to our critic, "may form an aerial or immersed mycelial layer, the consistency of which is either loose or plectenchymatic (pseudoparenchymatic)." That these bodies are to be regarded as stromata rather than as sclerotia was the idea intended to be conferred in the original statement.

The fungus studied at Raleigh was not *Verticillium albo-atrum*, but a species of Fusarium, which in view of the present confusion within the genus was not inappropriately designated *F. vasinfectum* Atkinson, since the type host of that species (cotton) is sufficiently closely related to okra to justify such a provisional reference of the fungus in question.

As no mycologist will entertain, even for a moment, the idea that all fungi, even of a given order, which attack a common host must per se be referred to the same species without first making a careful comparison of the various material, we must conclude from the statement of Doctor Wollenweber that there appear to be two wilt diseases of okra in this country, both showing the same symptoms, but caused by quite distinct and comparatively unrelated fungi, unless by some chance the material which he studied possessed only immature or abnormal conidia. That Doctor Wollenweber should assume merely on the basis of the published account and without examining material of the North Carolina fungus that the species studied by Stevens and Wilson is identical with the one which he refers to as a species of Verticillium appears to be due to his

loose use of such terms as sclerotium and stroma. According to his own definitions of these terms, each of them, when applied to fungi in general, is capable of widely varying interpretation since they include bodies of entirely dissimilar origin and structure, to say nothing of the fact that in neither case are they of necessity constant either in their behavior or the part which they play in the life history of the fungus which produced them.

COLUMBIA UNIVERSITY

REVIEWS

Die Nekrose des Phloëms der Kartoffelpflanze, die Ursache der Blattrollkrankheit. Quanjer, H. M. Mededeelingen van Rijks Hoogere Land-Tuin- en Boschbowschool (Wageningen, Holland). Deel **6**: 40–80. Taf. 2–9. 1913.

This paper takes up the anatomical and physiological questions relating to the leaf roll of the potato. The author finds that the chief cause of the disease shows itself in the phloëm strands. The sieve tubes are shrunken so that the walls and lumina of the single tubes cannot be differentiated. This shrunken tissue is yellowed, and with acids and caustic potash gives the characteristic reactions of lignified cells. Another variation from the normal is the shortening of the members of the sieve tubes in the mature internodes of the diseased plants.

The physiological disturbances are traced back to the shrinking of the phloëm strands, which causes a checking of the sap flow, thereby indirectly producing the disease symptoms, such as rolling of the lead, dwarfing, aerial tubers, etc. The occurrence of oxidizing enzymes in the plants is considered to be a response of the plant to the stoppage of the sieve tubes, and not the cause of the disease.

The statements made are logically brought out, but the failure of the author to go into detail as to the experimental evidence on which they are based considerably weakens the points made.

The report is valuable, however, because it opens up new lines of work on this important disease.

J. C. Gilman

Color Standards and Color Nomenclature. Ridgeway, Robert. Published by the author, Washington, D. C. Octavo, 43 pages, 53 colored plates. Price, $8.00.[1] 1912.

Exactness and precision are of the utmost importance in phytopathology, as in all other branches of science, and any practical assistance in attaining these ends should be welcomed and utilized by all. Color standards and nomenclature have until recently been in a very crude and unsatisfactory condition. The names applied to colors in descriptive pathology and botany have usually been taken from popular parlance. Such names do

[1] Copies may be obtained from Mrs. Robert Ridgeway, 3447 Oakwood Terrace N.W., Washington, D. C.

not convey any exact idea, and hence mean different things to different individuals. The book before us is intended to obviate this difficulty and provide biologists and allied scientists with an exact and adequate set of colors and color names.

The author published a work on the same subject over twenty-five years ago, containing 186 named colors. This of course was very incomplete and inadequate for scientific purposes, though it proved very useful and paved the way for something better. The present work, which contains 53 plates and 1115 named colors, is the result of the continued patient industry and investigation of Mr. Ridgeway, with the assistance of various artists and naturalists whose helo he gratefully acknowledges. The classification of the colors is based on the fundamental colors of the solar spectrum which are connected by the intermediate colors. The exact proportion of two or more colors necessary to produce any given color has been determined by the color wheel and Maxwell disks. This makes it possible to reproduce at any time any one of the 1115 colors if it were lost. Each of the colors is given a separate name besides being designated by a number and letter on the plate. It has required considerable ingenuity to find individual names for each of the colors. Some of them are consequently not so simple as one might wish. This seems however to have been unavoidable. The amount of manual labor involved in preparing each color separately and pasting the color slips on the plates has been great and this accounts in part for the rather high price of the book. The colors are as near permanent as it is possible to make them at present. The accurate definition of color terms, such as hue, tint, shade, and tone help greatly to clarify the subject. The book meets the needs of the biologist and pathologist better than any work of the kind that has yet appeared. Its adoption and use by phytopathologists and mycologists would greatly promote the advancement of our work, and it is to be hoped that it will find a place in the library of every scientific institution.

C. L. SHEAR

On the rotting of potato tubers by a new species of Phytophthora having a method of sexual reproduction hitherto undescribed. Pethybridge, G. H. Sci. Proc. Royal Dublin Soc. **13** (N. S.): 529-565, pl. 42-44. March 1913.

On pure culture of *Phytophthora infestans* deBary, and the development of oospores. Pethybridge, G. H. and Murphy, P. A. Sci. Proc. Royal Dublin Soc. **13** (N. S.): 566-588. pl. 45-46. March, 1913.

The first of these papers describes a new species, *Phytophthora erythroseptica*, causing a "pink rot" of potato tubers. The disease is prevalent

in the west of Ireland and the losses caused by it are considerable. The tubers attacked are at first resilient like india-rubber. A juice is exuded and soon the tubers dry up, becoming hard and woody. In all stages the mycelium resembles that of *P. infestans*. The conidia are formed only in watery solutions. They are developed sympodially, are ovate, with a blunt apex, and not provided with papillae. The size varies but averages 32μ by 20μ.

Antheridia and oogonia are produced in culture on separate hyphae. The antheridium is first formed and is a rounded structure which may be lateral, intercalary or terminal. The oogonial incept may be similarly formed. If the oogonial incept comes into contact with an antheridium, it enters into the interior of the latter, usually penetrating near the base; if it does not meet with an antheridium, development appears to be checked, at any rate no oogonium is formed. After a few hours it begins to grow, and soon breaks its way out through the summit of the antheridium, when the formation of the oogonium proper begins to take place. When the oogonium has attained full size, the passage of granular protoplasm ceases. Later the contents of the antheridium disappear. It is not certain whether fertilization occurs, but if so, it would appear to take place before the formation of the oosphere. Gradually a definite sphere is produced within the oogonium, the wall of which ultimately becomes about 2μ thick, and is very slightly tinged with a yellowish-brown color. The diameter of the oospores is between 29μ and 30μ.

After working out this method of oospore formation in *P. erythroseptica*, attention was directed to *P. infestans*. Pure cultures were grown and all the results were secured by means of these, following the methods developed in this country by Jones and Clinton. Oospores agreeing in all respects with those described by Clinton were secured on a modified form of oat agar. Search for resting spores in diseased potato tissues has thus far been fruitless. The oogonia arise as terminal swellings, the contents become dense and the wall brown in color, thus hiding from view changes undergone by the contents. These oogonia are pyriform to spherical in shape, averaging 38μ in diameter. When full grown a septum shuts the oogonium off from the contents of the hypha which bears it. The course of events where the antheridium is formed is probably similar to that in *P. erythroseptica*. It is finally observed that the antheridia are oval structures borne at the tips of hyphae. The oospore is contained within the spherical portion of the oogonium, the lower tapering portion of which is actually within, and surrounded by, the antheridium.

It is suggested that those species whose sexual organs are developed according to this new erythroseptica type should be retained in the genus Phytophthora, and that those which follow the cactorum type should be

placed in a new genus for which the name Nozemia is suggested. The genus Phytophthora as amended is to be removed from the family Peronosporaceae, and to constitute the sole member, at present, of the new family Phytophthoraceae. The members of the new family would be *P. erythroseptica*, *P. infestans*, *P. Phaseoli*, and (doubtfully) *P. Arecae*.

H. G. MACMILLAN

PHYTOPATHOLOGICAL NOTES

Melanose. Melanose is one of the diseases of citrus fruits which, because of its economic importance, has been the subject of investigation both by plant pathologists and physiologists. A glance at the literature of this malady impresses one strongly of the fact that a diversity of opinion exists as to its etiology. Announcements have appeared within the last few months in some of the scientific journals that the cause of this disease has been definitely established as the result of some work conducted at the Florida Experiment Station.[1] However, upon carefully reading the report of these investigations, it is not apparent to me from the evidence submitted that one is justified in concluding that *Phomopsis citri* Fawcett is the cause of melanose. It is the present purpose, therefore, merely to call attention to the nature of the proof submitted.

Plant pathologists have come to recognize, along with animal pathologists and professional bacteriologists, that proof of the pathogenic nature of an organism consists in its fulfillment of four cardinal requirements, which are known as Koch's rules. *Phomopsis citri* as the cause of melanose can, therefore, be justly submitted to these rules of proof in answer to the charge of pathogenicity which has been preferred against it.

As to the constant association of the organism with the disease several quotations only will be sufficient. "Microscopical examinations were made of these (referring to melanose spots on leaves, twigs, and fruits)[2] but in no case was a fungus or a bacterial organism connected with the spots which could be considered a cause of the disease. Stained sections of diseased tissues failed to show the presence of fungus growth within the affected or adjoining cells." In another portion of the text, however, an apparently different impression is left by the following statements: "Particles of fungus hyphae can sometimes be distinguished in the affected tissue. But it has not been demonstrated whether these are parts of the causal organism or are accidental."

Repeated attempts by the authors to isolate this organism from the diseased tissues failed to give satisfactory results, because of the fact that a species of Colletotrichum overran the cultures. That *Phomopsis citri*

[1] Floyd, B. F. and Stevens, H. E. Melanose and stem-end rot. Fla. Agr. Exp. Sta. Bul. 111: 1–16. figs. 9. December, 1912.

[2] Material in parentheses inserted by writer.

can be grown on artificial media is evident from the fact that Fawcett[1] isolated it from more than fifty different specimens of fruits and branches from more than twenty-five different localities.

The statements relative to inoculation into healthy plants are, unfortunately, so lacking in detail that the reader cannot account for the conclusions which are drawn. One method of inoculation consisted in drenching two trees with the drippings from dead twigs, then covering one tree for thirty-six hours with a bell jar and permitting the other to remain uncovered. Only the tree which was covered developed the characteristic spotting, from which it was concluded "that the spotting came from the dead twigs"! None of the fungi obtained in the plate cultures of unfiltered washings from dead twigs were capable of producing melanose. "No spotting has yet resulted by using the vegetative portion or mycelium of this fungus in infecting young tissue." Again, quoting in explanation of the infection work which involved the use of pure cultures of conidia, they say, "Apparently no vegetative growth of the fungus takes place within the infected tissue," so that no evidence is at hand relative to penetration. It is further suggested that the spots may be formed as a result of some stimulating or toxic effect produced by the germination or death of the conidia. This is indeed a wholly unique type of parasitism!

Further, there is no evidence submitted of attempts, either successful or otherwise, at reisolation from inoculations. There is, therefore, an apparent breach of every rule of proof in the evidence at hand as to *Phomopsis citri* being the cause of melanose.

FREDERICK A. WOLF

The type of Sphaeria radicalis Schw. Since our recent note[2] regarding this species, we have been able through the kindness of Prof. H. O. Juel, of the University of Upsala, Sweden, to examine asci and ascospores from the type specimen which was sent by Schweinitz to Fries and evidently used by Fries in the preparation of his description.[3]

We wish to express here our gratitude to Professor Juel for his courtesy in helping us to determine beyond any reasonable doubt the identity of this fungus. But one autograph specimen of this from Schweinitz could be found in Fries' Herbarium. It is labeled "*Sphaeria radicalis* L. v. S. Salem." It consists of two pieces of bark apparently from an oak root. One piece shows distinct perithecia with necks and ostioles agreeing with

[1] Fawcett, H. S. The cause of stem-end rot of citrus fruits (Phomopsis citri n. sp.) Phytopathology **2**: 109–113, pls. 8–9. 1912.

[2] Phytopathology **3**: 61. February, 1913.

[3] Elenchus Fungorum, Sistens Commentarium in Systema Mycologicum. **2**: 73. 1828.

Fries' description. The other piece seems to show pycnidia only. Measurements of nearly 100 ascospores from this specimen range from 5.5 to 9.2 by 2.7 to 3.8 microns. In all the characters studied the specimen agrees essentially with typical material of *Endothia virginiana* And. & And. kindly sent us by Mr. P. J. Anderson. Our measurements of ascospores from Anderson's specimen were 5 to 9 by 2.8 to 3.8. These differ somewhat from the measurements given in the original description of *Endothia virginiana*. There seems to be no doubt, however, of the identity of these two species. We have recently collected typical specimens of *Endothia radicalis* (Schw.) in the type locality, Salem, N. C. The species does not appear to have been collected, as yet, north or east of York County, Pennsylvania.

C. L. SHEAR

Auricularia mesenterica (Dicks.) Pers. This fungus is very common in Europe. Several collections made by the writer in the deciduous forests of Germany and Austria show it associated with diseased roots of living trees, especially those of *Quercus pedunculata* and *Fagus silvatica*, although it is more often found on dead roots and branches lying about in the forest. The plant seems to be very rare in the United States and few authentic specimens are recorded for this country. It has been reported by Frost from the eastern states and according to Lloyd, has recently been collected in western Canada.

During the fall of the past year two collections of the fungus have been made on dead roots of *Betula occidentalis* in the Bitter Root Mountains, Lolo National Forest, Montana. These collections show a great variety in form and markings of the upper surface. The form showing alternate smooth and hairy zones, formally called *A. lobata*, is less common. The fact that all these forms are found in the same collection indicates that they are one and the same species. The peculiarly wrinkled hymenium, and minute structure of the same, is identical in all. The discovery of this fungus in the western United States is another instance of the wide distribution of a plant supposed to be confined to rather narrow limits.

JAMES R. WEIR

Ginseng diseases. The extension of the work on ginseng diseases that has been under way for the past two years in coöperation between the Cornell Experiment Station and the Bureau of Plant Industry was provided for by the last Congress. The new work will extend the coöperation to the Experiment Stations in Michigan and Wisconsin. Mr. Joseph Rosenbaum will continue as general project leader working especially on soft rots and spraying demonstrations for Alternaria and mildew. Mr.

J. A. McClintock will work in Michigan on nematode diseases under the direction of Dr. E. A. Bessey, and Mr. J. W. Brann in Wisconsin on diseases of seedlings and soil treatment under the direction of Prof. L. R. Jones. Ginseng troubles in Pennsylvania, Ohio and other states will also receive attention.

Foreign reviews of American publications. American plant pathologists are requested to send advance copies of their publications to Dr. O. Appel, Kaiserliche Biologische Anstalt, Dahlem, Berlin, Germany, who has kindly offered to secure the prompt publication of reviews.

Federal Horticultural Board. Dr. Perley Spaulding, Pathologist in the Office of Forest Pathology, Bureau of Plant Industry, has been appointed pathologist to the Federal Horticultural Board. Dr. Spaulding will investigate for the Board problems relating to inspection and quarantine against plant diseases, and will assist in organizing an inspection service for the outlying propagating stations of the United States Department of Agriculture. Mr. E. R. Sasser has received a similar appointment as entomological inspector.

International conference on phytopathology. The French government recently extended to the United States an invitation to participate in their International Conference on Phytopathology to be held in Rome on April 25 for the purpose of preparing a draft of an international agreement to be presented to the International Institute of Agriculture which opened its sessions in Rome on May 6. It was found impracticable to accept this invitation on account of the late date of its receipt and because of a provision enacted by the last Congress which requires special authority to be granted by Congress before such an invitation can be accepted or extended.

Personals. Dr. H. B. Humphrey, recently head of the Department of Botany in the Experiment Station and State College of Washington, has been appointed pathologist in Cereal Disease Investigations in the Bureau of Plant Industry, succeeding Mr. E. C. Johnson. Dr. Humphrey is succeeded at Pullman by Dr. Ira D. Cardiff.

John G. Hall, recently associate professor of botany and forestry in Clemson College, has been appointed plant pathologist in the Washington College and Station.

N. Rex Hunt, recently district horticultural inspector for the Okanogan District, British Columbia, has been appointed scientific assistant in the Bureau of Plant Industry.

Anthony Berg, a graduate student in plant pathology at the University of Wisconsin, has been appointed assistant plant pathologist of the West Virginia Experiment Station.

Dr. Erwin F. Smith has been elected to membership in the National Academy of Sciences. The Academy now numbers 125 members, of whom 10 are botanists, viz. Campbell, Coulter, Farlow, Goodale, Harper, Sargent, Smith, Thaxter, Trelease, White. There are two botanists among the foreign associates, DeVries and Pfeffer. Among deceased members the Academy numbered the following botanists, Englemann, Gray, Lesquereaux, Sullivant, Torrey, Tuckerman, Watson: and the following foreign associates, Bornet, Alph. de Candolle, J. D. Hooker, Sachs, and Strasburger.

H. H. Whetzel, professor of plant pathology, Cornell University, sailed June 11 for Bremen. From there he goes direct to Esbjerg, Denmark, where he will join Dr. F. Kölpin Ravn for a botanical excursion with the International Association of Botanists which meets in Denmark the latter part of June. He will spend his summer in the Hartz Mountains, studying the language and collecting pathological material. He will work during the winter with Professor Klebs at Heidelberg and will spend the following summer visiting plant pathologists and experiment stations on the continent. He expects to return September, 1914.

Two Fungi as Causal Agents in Gummosis of Lemon Trees in California. The disease known as gummosis of lemon trees in California is characterized by the dying of areas of bark and the exudation of large quantities of gum above the bud union. That certain types of this disease can be induced in large healthy trees with cultures of fungi has been shown as the result of a series of inoculations during the past year. It was first found that typical cases of gummosis could be transmitted from diseased to healthy trees by inoculations with bits of discolored bark or wood cut out at the advancing margins of diseased areas. Bits of exuded gum or pieces of tissue near the centers of the diseased areas already permeated with gum, in most cases failed to transmit the disease.

In making the first studies of lemon gummosis in the orchards, it was found that there were at least two types of gummosis, one in which the dead bark remained hard, without outward evidence of fungi during the progress of the disease, and one in which the dead bark was at first soft with a later development of fungi upon the surface during damp weather By a series of inoculations with a number of organisms isolated from both types of the disease, it has been discovered that cultures of *Pythiacystis citrophthora* Sm. & Sm. (the brown rot organism) are capable of

inducing the former, and that cultures of *Botrytis* sp., probably a strain of *Botrytis vulgaris*, are capable of inducing the latter type.

That the mere cutting through the bark for the purpose of making the inoculations was not sufficient to induce the disease was shown by making cuts without inoculation in the opposite side of the same trees. These, when protected from contamination, invariably healed without gumming. As additional checks on some of the inoculations with diseased tissue, bits of healthy tissue of the same size were inserted into cuts on the opposite side of the same set of trees. These also healed readily without gumming.

Some months after inoculation, both these fungi, *Pythiacystis citrophthora* and *Botrytis* sp. were reisolated from the inner bark at the advancing edges of discolored areas, each from its own type of gummosis. A number of different kinds of injuries were made in the same set of trees, such as pounding with a hammer, boring with an augur, cutting and slitting the bark, and striking it with the heel of the shoe, etc. These wounds all healed up without gumming, provided the wounds were made with sterilized tools on bark surfaces that had previously been cleansed or sterilized. Similar wounds, however, most of them on the opposite sides of the same set of trees, when infected with cultures of Botrytis were almost always followed by copious gumming and dying of the bark over considerable areas.

Other fungi isolated from diseased tissue and shown by inoculation to be capable of inducing more or less gum with only slight injury to the bark, as compared to the two fungi above mentioned, were *Penicillium roseum*, *Alternaria* sp., and *Fusarium* sp.

That only certain organisms are capable of inducing gum even in wounds, was shown by inoculations into cuts with a number of different kinds of bacteria isolated from diseased tissue, *Penicillium digitatum*, *Cladosporium* sp. from decaying fruits, and *Mucor* sp. from dead roots, without so far producing any effect.

Further investigation of other fungi in relation to gumming is being carried out. A more detailed account of the experiments on which these statements are based is being prepared for a later publication.

H. S. FAWCETT

The nature of the relation, described above, between certain fungi and gummosis has been made the subject of investigation. It has been found that in the discolored bark immediately surrounding the area of gumming there is a substance, filtrable through a Chamberland filter, which is capable of producing gumming when introduced under the bark of a healthy lemon tree. In these experiments the infected bark was ground with sand

and water, the liquid filtered off, and injected under the bark of a healthy tree with a pipette, under sterile conditions. Similar wounds caused no gumming. The liquid used showed the absence of fungus spores and bacteria. It showed the presence of large amounts of oxidase and amylase. In the course of the investigation the effect of boiling the liquid was tried; no gum was produced, while the same liquid, unboiled, caused gumming on the other side of the same tree. Only one experiment of this nature has so far been tried. In no case has the liquid (except when boiled) failed to produce gumming. The question of the presence of active enzymes and their possible connection with gumming is being further investigated.

H. D. YOUNG

The Federal Horticultural Board held hearings on May 20 on the subjects of the pink bollworm of cotton and the white pine blister rust.

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